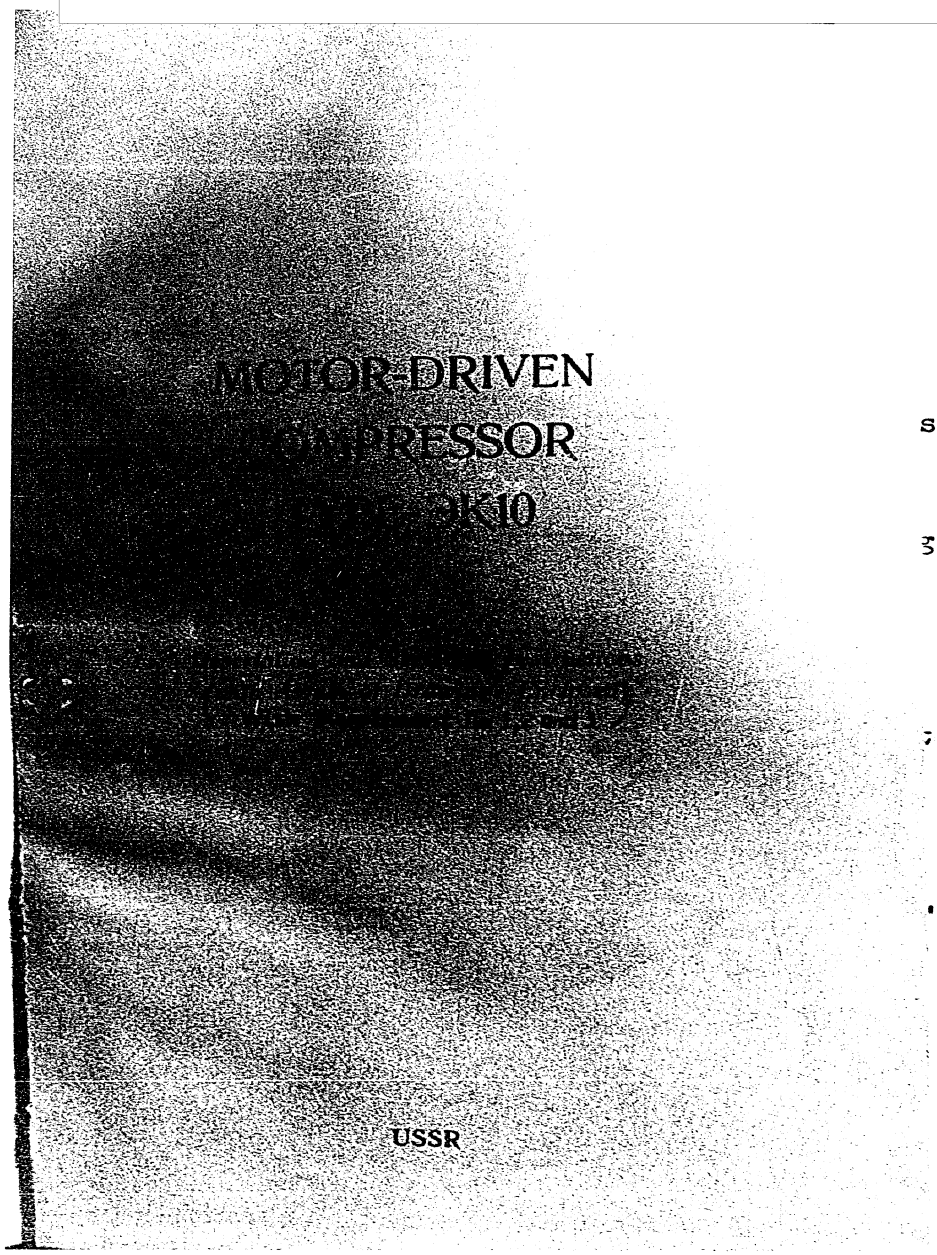
50X1-HUM

SECRET

50X1-HUM



SECRET

50X1-HUM

Part I

DESCRIPTION OF COMPRESSORS TYPE ЭК10

Stop springs, items 58 and 64 are not installed. 1st and 2nd stage suction valves with one spring are substituted for valves with two springs.

The water pump with a rubber cup packing is substituted for a pump with an end packing.

In connection with the above-stated the texts of the description and servicing instructions and the drawings of the eliminated units should be considered annihilated.

The compressor is of a piston type, V-design, four-stage, cross-headless, enclosed version. Functions of the 1st stage are performed by two cylinders; the same is the case with the 2nd stage.

Piston stroke is 100 mm.

Cylinder bore, mm:

1st stage	155
2nd stage	136
3rd stage	42
4th stage	25

Part I

DESCRIPTION OF COMPRESSORS TYPE ЭК10

1. PURPOSE AND PRINCIPAL SPECIFICATIONS

The type ЭК10 motor-driven compressor is designed to compress air up to a pressure of 400 kg/sq.cm. The whole assembly comprises a compressor, type ЭК10-1, and an electric motor mounted on a common bed plate and coupled by means of a flexible coupling. The compressors are manufactured in two modifications which differ in (a) electric equipment, (b) bed plates, (c) sleeves to couple the shafts.

Specifications of the motor-driven compressors are given in Table 1.

Table 1

Specifications of Motor-Driven Compressors

Type of compressor	Type of electric motor	Rated speed of compressor shaft, r. p. m.	Current	Output, l/min, with counter-pressure		Power consumed, kW, with counter-pressure	
				200 kg/sq. cm	400 kg/sq. cm	200 kg/sq. cm	400 kg/sq. cm
ЭК10—1	АМП 39,5 25	1330	d. c.	at least 18.0	at least 10.0	not over 68	not over 75
ЭК7,5—1	АМ[redacted]102—6	975	d. c.	at least 13.0	at least 7.5	not over 55	not over 60

The compressor is of a piston-type, V-design, four-stage, cross-headless, enclosed version. Functions of the 1st stage are performed by two cylinders; the same is the case with the 2nd stage.

Piston stroke is 100 mm.

Cylinder bore, mm:

1st stage	155
2nd stage	136
3rd stage	42
4th stage	25

The lubrication system of compressor moving parts is of a forced-feed closed circulation type.

The cooling system is of a forced-feed type. Cooling is effected by a flow of sea or fresh water.

The water pump is of a vortex type.

The compressor is driven directly by an electric motor through a flexible pin coupling. The direction of rotation is clockwise (when viewed from the electric motor end).

Overall dimensions and weight of the motor-driven compressor are given in Table 2.

Table 2

Overall Dimensions and Weight Data

Description	Type of compressor	
	ЭК10-1М	ЭК7,5-1
Length, mm	1860	1710
Width, mm	880	880
Height from supporting surface (under shock absorbers) of bed plate up to top point of compressor, mm	~~1290~~ 1360	1345
Weight less water and oil, kg (compressor together with electric motor mounted on bed plate, pressure gauge panel with pressure gauge pipes and extension electric starting equipment)	2220	1600
Weight with water and oil, kg (compressor together with electric motor mounted on bed plate, pressure gauge panel with pressure gauge pipes and extension electric starting equipment)	not over 2270	not over 1650

2. GENERAL DESCRIPTION

(See Album of Drawings, Sheet 35)

The compressor compresses atmospheric air in four stages in succession. Air is sucked in through a silencer and suction receivers. The silencer is intended to damp suction noise. It is mounted on the 1st-stage cooler. The suction receivers are mounted on the 1st- and 2nd-stage cylinders.

The silencer operates as an acoustic filter and is essentially a welded box of an oval cross-section having three resonant cavities which are designed so as to damp most intensive components of the air suction noise. Gas-dynamic losses in the silen-

cer and suction receivers are but negligible and, in fact, exert no effect on the compressor output capacity.

The 1st-stage system consists of two chambers situated in the top portion of cylinders *4* and *23*. The 2nd-stage system consists also of two chambers situated in the middle portion of cylinders *4* and *23*. The 3rd- and 4th-stage systems consist of one chamber each, situated in cylinders *21* and *9* respectively.

The compressor crankcase *2* is of a welded box-like structure. On the top flanges of the crankcase there are fixed cylinders arranged in two V-type rows, at an angle of 60°.

In the left-hand bank (as viewed from the pumps end) there are the 1st-, 2nd- and 4th-stage cylinders, while in the right-hand bank there are the 1st-, 2nd- and 3rd-stage cylinders. All cylinders are made as separate castings.

The 3rd- and 4th-stage cylinders *21* and *9* are fastened by means of studs to the 1st- and 2nd-stage cylinders *4* and *23* and serve also as the covers thereof. Forged covers *20* and *10* of the 3rd- and 4th-stage cylinders are fixed to the top ends of these cylinders by means of studs.

All the compressor cylinder chambers are furnished with water jackets where sea water can circulate. The top portion of each 1st- and 2nd-stages cylinder is fitted with ten suction valves *7*. Each 3rd-stage cylinder is fitted with nine 1st-stage delivery valves *16*; the same is the case with the 4th-stage cylinders. The middle portion of each 1st- and 2nd-stage cylinder is fitted with four suction valves *25* and four delivery valves *6* of 2nd-stage.

Screwed in the 3rd-stage cylinder cover *20* are two suction valves *19* and two delivery valves *17*. In the 4th-stage cylinder cover *10* are two suction valves *38* and two delivery valves *39*. All the valves are of a self-acting disc type.

Crankshaft *35* rotates in two roller bearings mounted in the crankcase seats. With the crankshaft journal there are joined two connecting rods *26* through end bearings fitted with babbited brasses.

The connecting rods are joined with the 1st- and 2nd-stage pistons *22* and *8* by means of wrist pins *30*, which are prevented from longitudinal displacement with the help of plugs *31*. The wrist pins are rested in bronze bushes *32* pressed into pivots *24*.

To cool air after each compression stage, the compressor is equipped with the 1st-, 2nd-, 3rd- and 4th-stage coolers. The 1st- and 2nd-stage coolers are of a tubular type; the 3rd- and 4th-stage coolers are coiled. The 2nd-, 3rd- and 4th-stage coolers *13* are arranged in a common housing, while the 1st-stage cooler *14* has a separate one. The 2nd-, 3rd- and 4th-stage coolers housing is situated between the cylinder banks and is fixed to holders *15* by means of studs, which holders are fastened to the

crankcase brackets. The 1st-stage cooler housing is fixed by means of studs to the 2nd-, 3rd- and 4th-stage coolers housing.

To cool oil circulating in the closed system serves a cooler *36* mounted on the front wall (when viewing from the pumps end) of the crankcase pan. In the oil cooler housing there is built-in an oil filter *37*, which serves for a coarse cleaning of the oil.

Cooling of air and oil in coolers *13*, *14* and *36* is effected by sea water delivered by vortex pump *42* mounted on transmission cover *40*. The pump is driven by the crankshaft through skew gear *33*.

The surfaces which are in contact with sea water have anti-corrosive coating made by electro-plating or varnishing. For same purpose protectors are provided in all cylinders, 1st-stage cooler and water pump housing.

The lubrication system of the compressor moving parts (crank gear) is of a forced-feed, closed circulation type.

Oil feed is accomplished by means of gear pump *41* mounted on transmission-cover *40*. The pump is driven by the crankshaft through skew gear *33*.

The 1st-stage cylinders and pistons are lubricated with oil coming from 2nd-stage cylinder chambers as well as with the air vapours sucked out of the crankcase through a special pipe, oil catcher and two 1st-stage suction valves (one suction valve per cylinder row).

The 2nd-stage cylinders and pistons are lubricated with the oil splashed by the compressor crank gear.

The 3rd- and 4th-stage cylinders and pistons are lubricated with oil carried with the air drawn from the 2nd- and 3rd-stage cylinders, respectively.

All the compressor stages are furnished with safety valves to prevent an infinite pressure rise, should the compressor be out of order. The 1st-stage safety valve *28* is mounted on the cooler of the same stage. The 2nd- and 3rd-stage safety valves *18* and *11* are fitted in special seats above the 3rd- and 4th-stage suction valves, respectively, in the cylinder covers of these stages.

The 4th-stage safety valve *5* is mounted in a special seat of the 4th-stage water-and-oil separator.

To protect the body of the 2nd-, 3rd- and 4th-stage cooler against breakdown (should compressed air penetrate into the water jacket space) there is a rubber membrane placed in the body of the 2nd-, 3rd- and 4th-stage coolers housing.

To clean the cooled air of steam and oil vapour condensate the compressor is provided with the 1st- and 4th-stage water-and-oil separators *34* and *3* fixed to the crankcase.

The compressor operates as follows. When the piston travels downward, vacuum is created in the 1st-stage cylinder. The at-

mospheric pressure makes the 1st-stage suction valve *7* open and the atmospheric air starts to come into the cylinder. When the piston gets to its lowest dead point the suction cycle is over. As soon as the piston starts its upward motion, the suction valves *7* get closed and the air in the cylinder is subjected to compression, which is accompanied by a rise of its temperature. When the pressure inside the cylinder gets somewhat higher than that after delivery valves *16*, the latter open automatically.

A further upward travel of the piston will force the air out of the cylinder through delivery valves *16* into the 1st-stage cooler. Compression of air in the 2nd-, 3rd- and 4th-stage cylinders makes a similar picture. An upward travel of the piston results in sucking of air into the 2nd-stage chamber, while a downward motion of the piston makes the air compressed. A complete cycle of air compression in each cylinder, i. e. suction, compression and discharge is performed during one revolution of the crankshaft.

On leaving the cylinders the compressed air is cooled in coolers of respective stages.

After passing through the 1st- and 4th-stage coolers the air proceeds into the water-and-oil separators of the respective stages where water steam condensate and oil are removed. Out of the 4th-stage water-and-oil separator the air is forced into air storage bottles.

A more detailed picture of the order of air passage through cylinders, coolers and water-and-oil separators is given in the elementary diagram of the compressor (Album of Drawings, Sheet 37).

Pressures of the air, water and oil are controlled by means of pressure gauges mounted on a remote-type panel (see Album of Drawings, Sheet 34).

Pressure gauge readings for each stage are to be within limits indicated in Table 3, provided the compressor operates normally under rated load and the cooling water temperature is not over 30° C.

Table 3

Pressure in Compressor Stages

Stage	Pressure, kg/sq. cm	
	with counter-pressure after 4th stage	
	150 kg/sq. cm	200 kg/sq. cm
1st	3.8 to 5.0	3.6 to 4.8
2nd	24 to 32	22 to 27
3rd	100 to 115	80 to 95

3. DESCRIPTION OF MAIN ASSEMBLIES

CRANKCASE

(See Album of Drawings, Sheets 35 and 1)

Crankcase *2* presents a welded steel box with openings in its walls and in two upper inclined flanges *50*. To fix the crankcase to the bed plate there serve two feet *56* welded to the side and end walls *55* and *47*.

Openings *A* have removable covers *54* and are designed for assembling, disassembling and inspecting the lower bearings of the connecting rods. Openings *Б* and *В* in supports *52* and *53* are intended to enable mounting the crankshaft bearings in place.

Fixed to flange *51* on the end wall at the side opposite to the compressor drive end is transmission cover *40* with water and oil feed pumps mounted thereon. The seat for the crankshaft bearing is fixed to support *53* at the drive end. Inclined flange *50* has a threaded hole *Г* for a pipe which serves to suck the air with suspended oil in it from the crankcase through an oil catcher into the 1st-stage cylinder.

To plates *57* welded to the crankcase bottom there is fixed a pan which serves as an oil collector. In the crankcase bottom there is a hole *Д* for oil to flow out of the crankcase into the pan. The hole is fitted with screen *27*.

To the end walls of the crankcase there are welded brackets *49* serving for the compressor coolers to be mounted thereon.

Bracket ribs *48* serve as supports for a rope in case the crankcase or the whole of the compressor has to be lifted in the process of its handling.

Either end wall *47* has threaded holes *Е* for bolts to fasten the 1st- and 4th-stage water-and-oil separators.

Two cylinders of the 1st- and 2nd-stages are mounted on the crankcase. These cylinders are centered in the bores of flanges *50* by means of the 2nd-stage liners.

The joint between the cylinders and crankcase is sealed with a gasket of drafting paper.

1st- AND 2nd-STAGE CYLINDERS

(See Album of Drawings, Sheets 35 and 2)

The 1st- and 2nd-stage cylinders are made as an integral cast-iron casting. The 1st-, 2nd- and 3rd-stage cylinder casting is identical in design with the 1st-, 2nd- and 4th-stage cylinder casting. With respect to the arrangement of the air chambers, water jacket spaces, valve seats and flanges the cylinder *23* of

the 1st-, 2nd- and 3rd-stage cylinder row is a mirror image of the cylinder *4* of the 1st-, 2nd- and 4th-stage cylinder row. At the top portion of each cylinder there are ten 1st-stage suction valves *7*. Screwed in the 1st- and 2nd-stage cylinder top end are studs *59* serving as fasteners of the 3rd- and 4th-stage cylinders.

Channels *Г* and *B* in the castings serve as 2nd-stage inlet and outlet ports, respectively. Four suction valves *25* and four delivery valves *6* of the 2nd-stage are placed in the walls of channels *B* and *Г*, respectively.

Each valve seat is closed with plug *62*. To prevent the valves from self-unscrewing each valve is pressed down by check spring *58*.

Pressed in the cylinder is 2nd-stage liner *61* which, together with the 1st-stage cylinder, serves as a guide for the 1st- and 2nd-stage piston. The liner centers the cylinder in the respective crankcase opening.

To prevent the compressed air from leaking out of the 2nd-stage cylinder chamber into the crankcase or just into the outside each 2nd-stage liner has two rubber packing rings *60* mounted thereon; in the process of fitting the liner into the cylinder the packing rings are compressed in the liner grooves thereby creating the required tightness.

The walls of both the cylinder and its air chamber are cooled with a flow of water available in space *Д*. Cock *63* is intended to drain the cooling water out of the cylinder.

3rd-STAGE CYLINDER

(See Album of Drawings, Sheets 35 and 3)

3rd-stage cylinder *21* is an iron casting. Pressed in the cylinder is a cast-iron liner *69* having three annular grooves with rubber packing rings *65* fitted therein. The two lower rings are intended to prevent the leakage of compressed air from the 1st-stage cylinder chamber into the water jacket space of the 3rd-stage cylinder. The upper ring serves to prevent outleakage of water.

At the lower portion of the 3rd-stage cylinder which serves also as a cover of the 1st-stage cylinder there are nine 1st-stage delivery valves *16*, each being pressed down by check spring *58*. Above each valve there is placed plug *62*. In the cylinder top end there are screwed four studs *68* serving as fasteners of the 3rd-stage cylinder cover *20*.

The walls of the liner and air chambers are cooled with sea water, which enters through inlet ports in the cylinder bottom and leaves through outlet port in the top portion thereof. To protect the surfaces which are in contact with sea water there are installed zinc protectors *67*.

At the top portion of the cylinder there is mounted cock *63* which is intended to let the air go out of the cooling system in the process of filling the system with water.

4th-STAGE CYLINDER

(See Album of Drawings, Sheets 35 and 4)

The design of the 4th-stage cylinder *9* is identical with that of the 3rd-stage cylinder *21*. Liner *70* pressed in the cylinder is made of steel.

3rd-STAGE CYLINDER COVER

(see Album of Drawings, Sheet 35 and 5)

The 3rd-stage cylinder cover *20* is forged of steel. The cover incorporates the 3rd-stage valves: two suction valves *19* and two delivery ones *17*. The suction valves are pressed down by check spring *64*; the delivery ones by check spring *58*. Above one of the suction valves and two delivery ones are placed plugs *62*.

Plug *72* placed above the other suction valve serves also as a seat for the 2nd-stage safety valve *18*.

The interior spaces of both the suction and delivery valves present channels drilled in the cylinder cover. The spaces of the valves of same function are intercommunicated through channels made by drilling. The suction and delivery spaces of the cover are intercommunicated with the 3rd-stage suction and delivery air pipelines through channels *A* and *B*, respectively, drilled in the flanges, and with the 3rd-stage cylinder chamber (via the valves) through channels *B* drilled in the cover.

Studs *74* serve as fasteners of the flanges of the suction and delivery pipelines.

4th-STAGE CYLINDER COVER

(see Album of Drawings, Sheets 35 and 6)

The 4th-stage cylinder cover *10* is forged of steel. In the cover there are the 4th-stage valves: two delivery valves *39* and two suction ones *38*. Above one of the suction valves and two delivery ones there are placed plugs *76*. Plug *75* placed above the other suction valve serves also as a seat for the 3rd-stage safety valve *11*.

The interior spaces of both the suction and delivery valves present channels drilled in the cylinder cover. The spaces of the valves of same function are intercommunicated through channels made by drilling.

The valve seat spaces are intercommunicated with the 4th-stage suction and delivery pipelines through drilled channels *A* and *B* and with the 4th-stage cylinder chamber through a group of drilled channels *Б* and *Г*. Each group consists of seven drilled holes 3 mm in diameter and is intended to prevent fragments of valve discs from penetrating into the cylinder chamber, should any valve be broken.

Studs *74* serve as fasteners of the suction and delivery pipelines.

CRANKSHAFT

(see Album of Drawings, Sheets 35 and 7)

Crankshaft *35* has one crank. On the crankshaft are mounted two identical self-aligning roller bearings *85*, which serve as crankcase carriers of the crankshaft. To facilitate installing the crankshaft into the crankcase, one of the bearings rests in steel seat *84*.

The crankshaft has longitudinal and radial holes *A* serving to feed the compressor moving parts with lubricating oil. To balance inertia forces there are two counterweights *79* pressed on the crankshaft webs; each counterweight is also fastened to the crankshaft with a bolt and two cotter-pins. On the crankshaft tail *Б* (at the drive end) there is a slot for a half-coupling spline of the compressor drive. To prevent outleakage of oil the crankcase is furnished with cover *80* fitted with rubber sealing gland *82* of a frame self-adjusting type and with packing *83*; these seals secure a required tightness at the crankshaft end. The tightness between the crankcase and its cover is secured with rubber packing ring *81* and for bush *88* with rubber packing ring *89*.

On the crankshaft tail (at the pumps end) there are four annular grooves, where cast-iron elastic split rings *87* are placed. The rings are designed for a better packing at the crankshaft end which turns in the transmission cover opening, with the purpose of preventing the oil forced by pumps *41* into the crankshaft drilled passages from leaking through the opening in transmission cover *40* into the crankcase. The same crankshaft end carries skew gear *86* serving to drive the water and oil pumps.

CONNECTING RODS

(see Album of Drawings, Sheets 35 and 8)

Connecting rods *26* of the both cylinder banks are of an identical design. Each connecting rod comprises stem *91* with a small end and a split big end bearing. The stem is of a double T-section and has an inner passage *A* through which oil is fed to

bronze bushing *92* pressed into the small end of the connecting rod. The connecting rod big end bearing is fitted with steel split backing *95* lined with babbit. Either half of the backing is prevented from both angular and axial displacement with the help of lock *93*.

Both halves *96* and *97* of the bearing are joined with the stem *91* by means of two big end bolts *98*.

Between the connecting rod and the big end there is shim *94*, which is intended to adjust the clearance between the 1st- and 2nd-stage piston and the 2nd-stage cylinder liner determining the amount of the dead space in the 2nd-stage cylinder. Thickness of the shim is selected in the process of assembling.

A set of shims *90* placed between the halves of the big end bearing is used to adjust an oiling gap in the bearing bush *95* with babbit worn out.

1st-, 2nd- and 3rd-STAGE PISTON

(see Album of Drawings, Sheets 35 and 9)

The 1st-, 2nd- and 3rd-stage piston *22* is composed of two parts: 1st- and 2nd-stage piston *106* and 3rd-stage one *103*, both being joined by piston rod *105*. Two ball pivots of piston rod *105* are fixed to the 1st- and 2nd-stage and 3rd-stage pistons by means of split ball pivot *104* and binding nuts *101*. The nuts are locked by washers *102*. The ball-and-socket joint between the 1st- and 2nd-stage piston and the 3rd-stage one enables the 3rd-stage piston *103* to move in its cylinder without cocking, should any of the following cases take place:

(a) the 1st-, 2nd- and 3rd-stage cylinders are not coaxial;

(b) the 1st-, 2nd- and 3rd-stage cylinder axes are out of line angularly;

(c) the 1st- and 2nd-stage piston shows some cocking with respect to the cylinder it travels therein.

The 1st- and 2nd-stage piston *106* is of a stepped (differential) design and is cast of an aluminium alloy. The step of a greater diameter serves as the 1st-stage cylinder piston, which is fitted with four compression rings *100*; the step of a smaller diameter serves as the 2nd-stage cylinder piston, which is fitted with five compression rings *99*, the lowest ring serving also as an oil control one; the 3rd-stage piston *103* is fitted with eight compression rings *87*. All the compression rings are made of cast iron and have straight splits.

In the bosses of the 1st- and 2nd-stage piston there are screwed four pins *107*, which fasten duralumin pivot *24* to the 1st- and 2nd-stage piston.

1st-, 2nd- AND 4th-STAGE PISTON

(see Album of Drawings, Sheets 35 and 10)

The piston is composed of two parts: 1st- and 2nd-stage piston *111* and 4th-stage piston *108*. The pistons are joined by piston rod *109*, a ball-and-socket joint being similar to that of the 1st-, 2nd- and 3rd-stage row pistons.

The 1st- and 2nd-stage piston *111* of the 1st-, 2nd- and 4th-stage row is identical in design with the 1st- and 2nd-stage piston *106* of the 1st-, 2nd- and 3rd-stage row described above (see para 9).

The 4th-stage piston *108* is made of bronze. To secure an adequate tightness between the piston and cylinder liner walls there is a labyrinth consisting of eleven grooves equally spaced along the piston body.

The binding nut is locked in the 4th-stage piston by means of screw *110* which is punched therein.

SUCTION AND DELIVERY VALVES

(see Album of Drawings, Sheets 35, 11, 12, 13, 14, 15, 16, 17 and 18)

The compressor is equipped with 62 self-acting spheric disc valves:

(a) 20 suction valves *7* and 18 delivery valves *16* in the 1st-stage system;

(b) 8 suction valves *25* and 8 delivery valves *6* in the 2nd-stage system;

(c) 2 suction valves *19* and 2 delivery valves *17* in the 3rd-stage system;

(d) 2 suction valves *38* and 2 delivery valves *39* in the 4th-stage system.

Diameter of the nominal opening is equal to: 14 mm for the 1st-stage suction valves; 12 mm for the 1st-stage delivery valves and for all the 2nd- and 3rd-stage valves; 10 mm for the 4th-stage valves.

The suction valves of 1st and 2nd stages are of an identical design (see Sheets 11 and 12). They comprise the following members: valve body *113*, arrester *114* pressed in the body, spring *115*, disc *116* and valve seat *117*.

The delivery valves of the 1st and 2nd stages are also of an identical design and comprise five members: valve seat *118*, disc *116*, spring *120*, valve cup *121* and binding nut *122* screwed in the valve seat (see Sheets 14 and 15).

The 3rd-stage suction valve (see Sheet 13) consists of the following members: valve body *113*, arrester *114* pressed in the

body, two springs *115* and *125*, bushing *275* centering spring *115* and valve seat *117*.

The 3rd-stage delivery valve (Sheet 16) comprises four members: valve body *123*, disc *116*, two springs *115* and *125*, bushing *275* and arrester *126* screwed in the valve body. The suction and delivery valve of the 4th stage (Sheets 17 and 18) comprise the following members: valve cup *127*, valve seat *128*, two springs *129* and *276*, bushing *275* to center spring *276* and disc *130*.

The valve disc lift values of all the stages are given in drawings of respective valves (see Album of Drawings).

The valve bodies of the 1st- and 2nd-stage systems and of the 3rd-stage system are fitted with protective screens which diminish the possibility of penetrating of disc fragments into cylinder chambers of respective stage.

The possibility of penetrating of disc fragments into the 4th-stage cylinder chamber is diminished with the help of holes 3 mm in diameter drilled in the cylinder cover, through which the valve space is intercommunicated with the cylinder chamber. All the valves are installed in their threaded seats using sealing gaskets.

4. AUXILIARY SYSTEMS

COOLING SYSTEM

(see Album of Drawings, Sheets 35, 32 and 19)

The system is designed for cooling the compressor cylinders as well as the air after each compression stage. Cooling is effected with sea water. The cooling system is of an open type with a consecutive flow of water through components thereof.

The cooling system comprises:

(a) vortex water pump *42*;

(b) 1st-stage cooler *14* and 2nd-, 3rd - and 4th-stage coolers *13*;

(c) water jacket spaces of ccmpressor cylinders;

(d) cooling water pipelines.

For the water piping diagram see Sheet 32 (Album of Drawings).

Pump *42* draws water through pipe *A* and delivers it into the 1st- and 2nd-stage cylinders of the 1st-, 2nd- and 4th-stage row. Through four sleeves *12* connecting the openings in the 1st- and 2nd-stage cylinder top end and those in the 4th-stage cylinder bottom, the water flows into the 4th-stage cylinder *9* and therefrom into the 2nd-, 3rd- and 4th-stage cooler *13*. Out of the 2nd-, 3rd- and 4th-stage cooler the water is delivered into the 1st- and 2nd-stage cylinder *23* of the 1st-, 2nd- and 3rd-stage row and

then through four by-pass sleeves into the 3rd-stage cylinder *21*. Out of the 3rd-stage cylinder the water proceeds into the 1st-stage cooler *14* and then into the outlet pipe. Out of the pump *42* the water comes also through pipe *E* into oil cooler *36* from where it proceeds into the outlet pipe.

The cooling system pipes are made of copper grade M3C.

To drain the water out of the cooling system there serve three cocks: one mounted on the 2nd-, 3rd- and 4th-stage cooler and two on the bottom portion of the 1st- and 2nd-stage cylinders.

To let the air out of the cooling system in the process of its filling with water there are cocks mounted on the 2nd-, 3rd- and 4th-stage cooler and on the top portion of the cylinders of the 3rd-and 4th-stages; the cocks serve also to check the water level in the cooler and cylinders.

Plug *C* in the suction pipe of the pump is provided for priming the pump with water prior to starting the compressor.

The pipe connecting the pump and cylinder *4* has a branch leading to the pressure gauge which measures the pressure head created by the pump.

WATER PUMP

(see Album of Drawings, Sheets 35 and 19)

The pump is of a vortex type. The output of the pump with a suction head of 3 m water and a counter-pressure of 1.0 to 1.5 gauge atm. is 70 litres per minute, at a compressor shaft speed of 985 r. p. m., or 80 litres per minute, at a shaft speed of 1330 r. p. m. The pump is driven by the crankshaft through two skew gears *33* and *143*. The pump impeller *136* has 36 blades on each side. The runner blades are arranged in channel *E* formed by pump housing *134* and pump cover *135*. The housing and cover of the pump are made as castings.

The impeller is mounted on shaft *142* and is fastened thereto with a key and a special screw *137* which is locked with a washer. The shaft turns in two ball bearings *132* and is prevented from axial displacement by its collar, spacer *141* and skew gear *143*. Clearances "*a*" and "*б*" should be within 0.2 and 0.25 mm and are adjusted in the process of assembling by means of a set of shims *133* and *138*. On the overhanging end of the shaft there is mounted the drive gear wheel *143* which is fastened with a spline and a nut.

The pump is fixed to transmission cover *40* by means of flange *B*. In the bearing housing *139* there is a hole *131*, which serves for filling the bearing housing with oil, in case the compressor is started after an overhaul or partial reassembling. The tightness of the water and oil spaces is secured with the help

of two packing rings *140* composed of rubber cup packings in brass holders and of locking springs.

If the compressor is installed above the waterline, a non-return valve and a screen filter should be mounted below the waterline (these are not included in the delivery set of the compressor).

AIR COOLERS

(See Album of Drawings, Sheets 35, 20 and 21)

The compressor is equipped with four air coolers (for each stage) and an oil cooler. The oil cooler as well as the 1st- and 2nd-stage air coolers are tubular. The 3rd- and 4th-stage air coolers are coiled; they are housed in a common casing with the 2nd-stage air cooler.

In the 1st-stage cooler and in the oil cooler the water circulates inside the tubes, while the air and, accordingly, the oil circulate in the inter-tube space. In the 2nd-, 3rd- and 4th-stage cooler the air circulates in the tubes, while the water does in the inter-tube space. The 1st-stage cooler and the 2nd-, 3rd- and 4th-stage one are arranged in between the cylinder bank and fastened on brackets *15* on the crankcase. Oil cooler *36* and its filter *37* are housed in a common cast casing and is suspended onto the wall of pan *1*.

1st-Stage Cooler

(see Album of Drawings, Sheets 20 and 35)

The 1st-stage cooler is of a tubular type and comprises tube bunch *153*, casing *152* and covers *148*. Tube bunch *153* consists of *121* copper tubes which are beaded in tube sheets *154* and *147*. The tube bunch is centered in the openings of the cooler flanges.

Plates *150* and fins *151* are designed for the air to laterally stream round tube bunch *153*. Plates *150* are mounted on the pipes of the bunch and soldered to their outer portions. Fins *151* serve also to prevent the plates from being displaced, should the soldering to the outer portions of the pipes get failed. The fins are soldered to tube sheets *154* and *147* as well as to plates *150*. Tube sheet *154* is rigidly clamped between casing *152* and cover *148*. Tune sheet *147* is of a "floating" type, i. e. it can freely move in the axial direction.

Such a design of the tube bunch fitted with a "floating" tube sheet provides for thermal expansion of the tubes heated by the hot air streaming round the tubes. The adequate tightness of the "floating" tube sheet is accomplished by means of two packing rings: a ring *145* made of lead at the end of the air chamber and a rubber ring *146*, at the end of the water jacket space.

Tightness of packing rings *145* and *146* is adjusted by screwing the cover *148* and ring *149* with the help of the nuts and pins serving as fasteners of cover *148*.

The compressed air enters and leaves the system through the branch pipes welded to the casing. To protect the surfaces in contact with the water against corrosion there are zinc protectors *156* fixed to covers *148*. The casing surfaces in contact with the air are painted with enamel, grade Ч-1, laid under a coat of varnish, grade Ч-2. The surfaces of cover *148*, which are in contact with the water, are cadmium plated.

In the cooler casing there is screwed the 1st-stage safety valve *28*.

2nd-, 3rd- and 4th-Stage Cooler

(see Album of Drawings, Sheets 21 and 35)

The cooler casing is composed of jacket *162* and flanges *160* and *166* soldered thereto. Inside the casing there are the 2nd-, 3rd- and 4th-stage sections (coolers) *181*, *178* and *177*.

The 2nd-stage cooler *181* is of a pipe type and presents a tube bunch consisting of *89* copper pipes with the ends beaded in tube sheets *182* and *164*. To the tube sheets of the 2nd-stage cooler there are fixed covers *159* and *168* fitted with lateral partitions. The air comes into the upper chamber of the right-hand cover and leaves out of the lower chamber of the left-hand cover thereby making two turns in the tube bunch, which serves as the 2nd-stage cooler. The left-hand tube sheet *182* is rigidly fixed to the casing cooler. The left-hand tube sheet *182* is rigidly fixed to the casing flange. The right-hand tube sheet sealed with rubber packing ring *165* is of a "floating" type and can freely move in the axial direction thereby securing the possibility of thermal expansion of the tubes.

To obtain an adequate counterflow of the cooling water and the air in all the sections and to increase the cooling water flow velocity, thereby intensifying the heat transfer, the tube bunch is housed in a jacket *163* which divides the water chamber of the 2nd-, 3rd- and 4th-stage cooler into two compartments.

The water comes into the 2nd-stage cooler chamber through opening *A* available in tube sheet *182* and through the space formed by deflector *161* soldered to jacket *163*.

Through opening *Б* the water proceeds to the 3rd- and 4th-stage cooler chamber and therefrom through opening *В* in tube sheet *182* into the water system pipe. Opening *Д* in jacket *163* serves to drain water out of the 2nd-stage cooler chamber.

Partitions *176* are designed for the air to laterally stream round tube bunch *181*. The partitions are mounted on the tubes of the bunch and soldered to their outer portions.

The 3rd- and 4th-stage coolers are of a coil type. The clearance between the turns of the adjacent coils is 4.0 mm.

To avoid the mutual friction between the turns and to diminish the vibration amplitude of the 3rd- and 4th-stage coils there are installed six rubber arresters *180* pressed to the coils by means of covers *179*; the arresters are spaced in the cooler casing (on Γ—Γ planes) at an angle of 120°. The coils are made of cupronickel alloy.

On the threaded ends of the 3rd- and 4th-stage coils there are screwed unions, which are led out through tube sheet *182* and cooler housing flange *166*; the unions are fixed also by soldering and locked with nuts *172*. At the places of their outlets the unions are sealed with rubber rings *174*, which are pressed down by rings *173* in the process of tightening the nuts *172* (the sealing member of only one union is shown in the drawing; the other three unions are sealed in a similar way).

On unions *171* there are screwed flanges *170* and to the latter flanges there are connected the flanges of the air inlet and outlet pipes of the 4th stage.

The 3rd-stage air conduits are connected to the 3rd-stage coil unions by means of captive nuts. To let the air go out of the water jacket space, when starting the compressor, or to drain the water, when stopping it, two cocks *63* are provided: an upper one and a lower one.

A rubber membrane in the cooler casing boss is provided to prevent the casing from being damaged, should the compressed air penetrate into the water jacket space (the membrane is not shown in the drawing).

WATER-AND-OIL SEPARATORS

(see Album of Drawings, Sheets 35, 22 and 23)

The compressor is equipped with 1st-stage and 4th-stage water-and-oil separators *34* and *3* which are suspended on the crankcase. The water-and-oil separators are designed to clean the compressed air of the oil carried from cylinders by the air as well as of suspended particles of water resulting from a partial condensation of the water steam, which takes place in the coolers in the process of cooling the air. Removal of water steam condensate and oil from the air in the water-and-oil separators is based on the difference in their specific gravity values and is accomplished by changing the direction and velocity of the air flow.

1st-Stage Water-and-Oil Separator

(see Album of Drawings, Sheets 22 and 35)

Water-and-oil separator housing *187* is welded of steel. To the housing is welded a flange serving to fasten the water-and-oil separator to the crankcase (not shown in the drawing). Air comes through inlet pipe *188* into an annular space available between pipes *189* and *190*; as the air moves tangentially with respect to the pipe walls it is imparted a spin within the space.

Under centrifugal forces the liquid particles are thrown off onto the wall of pipe *189* wherefrom they trickle down to the bottom portion of the water-and-oil separator, while the air leaves out of the water-and-oil separator through outlet pipe *190*.

To drain the condensate accumulated in the water-and-oil separator a union is screwed into boss *186*. To the union is connected the condensate outlet pipe.

4th-Stage Water-and-Oil Separator

(see Album of Drawings, Sheets 23 and 35)

Housing *191* of water-and-oil separator *3* is made of steel. To the housing there is welded a bracket serving to fasten the water-and-oil separator to the crankcase (not shown in the drawing). In the bore available at the top part of the housing there are mounted separator *192*, valve seat *193* fitted with ball *199*, two copper gaskets and nipple union *194* wherein the valve ball lift stop *195* is pressed. Separator *192* is equipped with a seven-turn coil and serves to maintain an air spin within annular space *A* available between the walls of housing *191* and the pipe coil unit of separator *192*.

As the air enters annular space *A* tangentially to the walls of housing *191* it is imparted a spin. Ball-type valve *199* serves as a non-return one preventing the air from flowing back into the compressor, should the latter stop suddenly.

Separation of the air from the condensate is based on the same principle as in the 1st-stage water-and-oil separator. Bottom *201* and union *200* serve as a condensate outlet and a pressure gauge connection respectively.

Spacer *197* between flange *198* and the upper end of nipple union *194* by means of bolts *196* serves to tighten the joint between the outlet pipe and the water-and-oil separator.

In housing body *191* of the water-and-oil separator there is a threaded seat (see dotted line in the drawing) intended for the 4th-stage safety valve to be placed and fixed thereto.

LUBRICATION SYSTEM

(see Album of Drawings, Sheets 24, 25, 26, 27, 33, 34 and 35)

The lubrication system comprises: (a) gear oil pump *41*; (b) oil cooler *36*; (c) oil filter *37*; (d) pan *1*; (e) oil pipes.

Compressor pan *1* is filled with oil through the filler hole available in the crankcase up to the level corresponding to mark "*B*" on dipstick *213*.

Gear pump *41* draws oil out of the pan through branch pipe *212* passing through an opening in pan *1* and forces it through the delivery pipe into the chamber of oil filter *37*, wherefrom the oil proceeds into oil cooler *36*.

In case filtering element of oil filter *37* gets clogged, the oil will proceed through by-pass valve *235*, escaping the filtering element, into channel "*Г*", which is in direct communication with the oil cooler. The pressure existing in the system is checked with the help of a pressure gauge available on the transmission cover and another pressure gauge mounted on the panel, both pressure gauges being directly connected with the oil inlet space in the transmission cover.

The pressure gauge available on the transmission cover serves to measure the oil pressure while starting the compressor and during short runs with a low temperature of the ambient air. The oil pressure at the transmission cover inlet is to be 0.5 to 0.6 kg/sq. cm.

Oil pump *41* has a built-in reducing valve *209* which is designed to prevent an excessive rise of pressure in the lubrication system and to adjust the oil pressure therein. The hole closed with plug *211* serves to drain the oil off the pan. The total weight of oil is equal to 11.8 kg, provided the oil level in the pan is as high as mark "*B*" on the dipstick, the latter being inserted into the pan down to the stop.

To raise the oil level from mark "H" up to mark "B" on the dipstick it is required to add 6.8 kg of oil.

Lubrication of Moving Parts (Crank Gear and Pistons)

The lubrication system of the compressor moving parts is of a forced-feed closed circulation type (see Album of Drawings, Sheet 33).

Out of the cooler the oil proceeds through the transmission cover *40* and tunnels drilled in crankshaft *35* to the big end bearings and therefrom through tunnels drilled in piston connecting rods *26* to the small end bearings.

The oil flowing out through passages drilled in the web and in the plug of the channel in the piston rod stem lubricates the crankshaft roller bearings as well as the bearings of the water

pump and the screw gears of both the water and oil pumps. The oil flowing out through the clearances in the piston rod bearings is splashed by the moving parts and lubricates the friction surfaces of the 2nd-stage cylinder liners and the 1st- and 2nd-stage pistons. The waste oil flows down into crankcase *2* wherefrom it proceeds into the compressor pan through screen *27* available in the crankcase bottom.

Lubrication of Cylinders

The friction surfaces of the 1st-stage cylinders are lubricated with the oil contained in the air drawn from the compressor crankcase through pipes *A*, *B* and *C* specially designed for the purpose, as well as with the oil coming through the compression rings of the 1st- and 2nd-stage pistons. To limit the amount of oil sucked-in from the crankcase through pipe *C* there is oil catcher *43* presenting a cylindrical vessel fitted with a set of screens. The separated oil flows out of the oil catcher through pipe *B* into the pan.

The process of lubrication of the friction surfaces of the 2nd-stage cylinder liners is described above. The friction surfaces of the 3rd- and 4th-stage cylinder liners are lubricated with the oil carried with the air coming out of the 2nd-stage cylinder.

Lubrication of Auxiliaries

The water pump bearings are lubricated with the oil which is splashed by the compressor moving parts and penetrates into the transmission cover cavity.

After being reassembled the water pump should be filled with oil in conformity with what is said in Item 9 of the Servicing Instructions; filling is performed through hole *A* available in the water pump bearing housing, whose hole is closed with plug *131*. (See Album of Drawings, Sheet 19).

Oil Pump

(see Album of Drawings, Sheets 24 and 25)

The pump is of a gear type and comprises the following principal members: housing *206*, cover *205*, shaft with driving pinion *208*, shaft with driven pinion *207* and main drive skew gear *203*. As bearings of the shafts there serve bronze bushings *204* and *202* pressed in housing *206* and cover *205*. The pump is fitted with built-in reducing valve *209* which is designed to let the oil pass out of the delivery chamber of the pump housing into the suction chamber, should the oil pressure inside the oil delivery conduit have risen higher than it is allowable.

The pump is mounted on transmission cover *40* and fixed with pins thereto. The pump is driven by the compressor crankshaft through two skew gears *33* and *203*.

Oil Cooler

(see Album of Drawings, Sheets 26 and 35)

The oil cooler and the oil filter are housed in a common casing *215*. The oil cooler comprise casing *215* and tube bunch *214* consisting of two tube sheets and 37 copper tubes.

The tube ends are beaded in the tube sheets and fixed by soldering. Tube sheet *224* is dead fixed with respect to casing *215* by means of strip *222*, which is fastened to casing *215* with two bolts *223*, and is tightly put into a slot milled in the tube sheet. Tube sheet *216* is of a "floating" type and can freely move in the axial direction thereby securing the possibility of a free thermal expansion of the tubes.

The interior spaces of the pipe frames are closed by cast covers *218* and *225* with cooling water inlet and outlet pipes soldered thereto.

To obtain a lateral streaming of the oil round the tubes there are partitions *220* soldered to the outer portions of the tubes. Circulation is of a counterflow type. The oil space is sealed with two rubber packing rings *219*. A hole closed with plug *221* serves to drain the oil off the cooler.

Oil Filter

(see Album of Drawings, Sheets 27 and 35)

The oil filter is a head member in the lubrication system and its function is to clean all the oil circulating over the forced-feed lubrication system.

Oil filter *37* comprises a filtering element, casing *215* and cap *230*. The filtering element presents a pack of circular filtering plates *231* interlaid with sprocket-shaped plates *232*, both being mounted on non-round rod *234*. The pack is placed between two washers *226* and rings *238* and is tightened by means of nut *234* locked with a washer. Pins *233* serve to fix the filtering element to filter cap *230*.

Between filtering plates *231* there are clearances 0.1 to 0.12 mm thick, where cleaning plates *228* (0.05 to 0.06 mm thick) are placed. The latter plates are mounted on pin *227* of a square cross-section, which pin is dead fixed to filter *230*. Cup *237* is joined with the pack of the plates and is tightly inserted into hole *K* drilled in the filter casing. Rod *234* is sealed in filter cap

230 by ring *229* made of oil-resistant rubber. Out of the pump the oil proceed into settler *Б* of the filter.

On leaving the settler the oil passes through slots available between the filtering plates and proceeds into vertical channels formed by cuts in the filtering plates and therefrom through a hole in washer *226* and ring *238* into cup *237* and channel *К*. Out of channel *К* the oil goes into the oil cooler chamber.

To clean the slots available between the filtering plates the pack of the plates *231* and *232* together with rod *234* is to be turned round its axis. To avoid a failure in oil feed, which may result from clogging of the filtering element, there is a by-pass ball-type valve *235* built in the filter casing. When the valve is opened the oil proceeds into channel *Г* and into the oil cooler directly out of settler *Б* escaping the filtering element. Coarse particles which contaminate the oil as well as any dirt will be accumulated in settler *Б* and then removed through a drain port closed with a plug.

BLOWING-OFF SYSTEM

(see Album of Drawings, Sheets 35 and 34)

The compressor blowing-off system is designed for:

(a) cleaning of the water-and-oil separators from oil-and-water emulsion (condensate) accumulated in the course of compressor operation; to this end the blowing-off valves are periodically made open for a short time;

(b) a partial decrease of load, when starting the compressor;

(c) drying of the cylinder chambers prior to stopping the compressor.

Blowing-off valves *260* and *263* of the 1st and 4th stages are mounted on the pressure gauge panel, which is installed outside the compressor on shock absorbers *261*.

The 2nd and 3rd stages are blown off through unions soldered to valves *262* of the pressure gauges of these stages.

COMPRESSOR PIPELINES

The compressor is equipped with the following pipelines:

(a) air pipeline;

(b) cooling water pipeline;

(c) oil pipeline;

(d) pressure gauge pipeline.

The layout diagrams of the air, cooling water, and oil pipelines are shown on sheets 31, 32 and 33, Album of drawings.

Nos.	Description	Clearances, mm: range of original setting values	maximum permissible working clearance
	3rd—stage	0.008 to 0.038	0.08
5	Piston ring lock gap:		
	1st stage	0.2 to 0.4	0.5
	2nd stage	0.2 to 0.4	1.5
	3rd stage	0.2 to 0.3	1.2
6	Diametral clearance between crankpin and big end bearing	0.03 to 0.09	0.15
7	Diametral clearance between piston pin and small end bushing	0.017 to 0.038	0.10
8	Diametral clearance between piston pin and 1st- and 2nd-stage piston pivot bushing	tension: 0.038 clearance: 0.035	clearance: 0.050
9	Total axial clearance between pinions and oil pump cover	0.06 to 0.08	0.10
10	Diametral clearance between oil pump axles and bearing bushes	0.016 to 0.052	0.1
11	Axial clearance between working wheel and housing of water pump	0.2 to 0.25	0.25
12	Axial clearance between working wheel and cover of water pump	0.2 to 0.25	0.25

Note: Values of the maximum permissible working clearances may be specified more precisely after a long-term wear test of the compressor.

I. INSTRUCTIONS FOR SERVICING THE MOTOR-DRIVEN COMPRESSOR IN OPERATION

Important! The attendant **may be allowed to operate the** compressor only after he **has thoroughly studied the Description** and Servicing Instructions **for the motor-driven compressor.**

[illegible] procedure performed should be noted down [illegible]

GENERAL ATTENDANCE AND MAINTENANCE

1. Keep clean the room where the compressor is installed.
2. Inspect regularly the compressor.
3. Keep the compressor clean, wiping it with rags daily.
4. Every day turn over the compressor crankshaft by 10 to 15 revolutions with the help of a small drawbar, the blow-off valves on all the stages being open. Insert the drawbar into radial holes accessible in the compressor half-coupling.
5. Every 100 hours of operation change oil in the pan, oil [illegible] and oil cooler; to this end first drain off the waste oil through corresponding drain openings and then pour fresh oil.
6. If the compressor is supposed to stay idle for over 6 or 7 days, regularly start the compressor and keep it running for at least 15 to 20 minutes, counter-pressure at the 4th-stage outlet [illegible]

[illegible] **got into the crankcase or into compressor lubri-** [illegible] **whole of the oil circulating in the lubrication**

PREPARATIONS FOR STARTING

[illegible] whether the **compressor is sound; for which** purpose

(a) inspect carefully the compressor;

(b) check thoroughly whether the **piston rod bolts and all the** accessible threaded joints are adequately **tightened, including the**

bolts fastening the compressor to its bed plate and the bed plate to the foundation;

(c) turn over the crankshaft by some 2 or 3 revolutions to make sure that it rotates easily.

8. With the help of the dipstick check the oil level in the compressor pan. Add, if necessary, well-filtered oil up to the level corresponding to mark "B" on the dipstick, which dipstick is to be inserted into the filter hole down to the stop.

Notes.

1. Never operate the compressor, if the oil level in the pan is lower than that corresponding to mark "H" on the dipstick, the latter being inserted into the filter hole down to the stop.

2. If the ambient temperature is under 6° C, warm the oil to be poured into the crankcase up to 20 to 30° C.

9. Fill the water pump bearing housing with oil. (The procedure is to be performed only when this did not take place in the process of installing and fastening the pump after an inspection or reassembling).

10. Check whether the pressure gauge valves of all the stages are open.

Open the 1st- and 4th-stage blow-off valves and set the blow-off needles of the 2nd- and 3rd-stage pressure gauge valves into their lower positions, thereby securing a possibility of blowing-off the 2nd and 3rd stages through the valves of the pressure gauges of these stages.

11. Fill the vortex pump and its suction pipe with water through a special opening available in the suction pipe; after the procedure is over, close the opening with its plug.

Note. The suction pipe is to be filled with water only when the pump is situated above the waterline.

12. Turn the oil filter axle through 3 or 4 revolutions.

13. Wipe the compressor with rags.

14. Open the cock available on the suction pipe of the cooling system (provided the cooling water is supplied from the board water mains).

STARTING, ATTENDANCE DURING OPERATION AND STOPPING

Starting

15. Start the electric motor.

16. Observe readings of the electric instruments.

Note. The electric motor should be attended in conformity with "Operating Instructions" supplied by the Manufacturer.

17. Check the supply of cooling water by opening the cocks on the 3rd- and 4th-stage cylinders and on the 2nd-, 3rd- and 4th-stage cooler. After the procedure is over, close the cocks.

18. Watch readings of the pressure gauges and adjust the valves so that the pulsation available in the piping will not be transmitted to the pressure gauges.

While starting the compressor with the 1st- and 4th-stage blow-off valves open, the pressure gauges should read the following pressure values, provided the cooling water temperature across the compressor inlet is not over 30° C.

The air pressure gauges, kg/sq. cm

1st stage	P= 3.6 to 4.8
2nd stage	P=20 to 26
3rd stage	P=33 to 47
4th stage	P= 0 to 25

The oil pressure gauge (mounted directly on the transmission cover) should read P=0.5 to 0.6 kg/sq. cm.

If the oil pressure gauge is mounted on the panel, its allowable reading limits should be determined individually in situ.

The water pressure gauge should read P=1.0 to 1.5 kg/sq. cm.

Note. If in the course of starting the compressor the oil pressure rises above 1.0 kg/sq.cm, relieve the oil by-pass valve spring by turning the valve adjuster by 2 or 3 revolutions. When the oil pressure has risen as the oil gets warmed up, tighten gradually the by-pass valve spring thereby adjusting the oil pressure within limits to be within 0.5 and 0.6 kg/sq. cm.

19. Watch readings of the pressure gauges and load gradually the compressor by successive closing the 1st- and 4th-stage blow-off valves and the blow-off openings of the 2nd- and 3rd-stage pressure gauge valves.

20. Open the shut-off valve on the delivery pipe, which communicates the compressor with the air storage bottles.

21. Close the blow-off valves of the divider.

Attendance During Operation

22. Always keep a watch over readings of the pressure gauges. Under proper functioning of the compressor the pressure gauges are to show the following approximate values (kg/sq. cm), provided the cooling water temperature across the compressor inlet is not over 30° C,

for 35-40 kg/sq. cm counter-pressure across the 4th-stage outlet:

1st stage	P= 3.8 to 5.0
2nd stage	P= 24 to 32

3rd stage	P = 100 to 115
lubrication system	P = 0.5 to 0.6
cooling system	P = 1.0 to 1.5

(b) at 200 kg/sq. cm counter-pressure across the 4th-stage outlet:

1st stage	P = 3.6 to 4.8
2nd stage	P = 22 to 27
3rd stage	P = 80 to 95
lubrication system	P = 0.5 to 0.6
cooling system	P = 1.0 to 1.5

23. Always listen to the sound of the operating compressor to timely detect abnormal knocks.

24. Keep watch over adequate cooling of the compressor, the water temperature at the compressor input should not exceed 30° C while the temperature of water leaving the compressor should not exceed that of water coming therein by more than 20° C. Otherwise an intense scale formation will take place on the self-acting valves and in all air pipes, which may cause an explosion of oil vapours available in the compressor.

25. Every 30 minutes blow off the 1st- and 4th-stage water- and oil separators in successive order, for which purpose open the blow-off valves.

26. Always check the tightness of all the joints available in the compressor, auxiliaries and piping. Check the tightness of the water pump gland by observing a value of the pressure across the water pump outlet.

Note. It is absolutely forbidden to tighten any joints when the pipeline is under pressure.

27. Every 8 hours of operation clean the slots between the [illegible] plates of the oil filter by turning over the rod and the [illegible] of plates mounted thereon by some 3 or 4 revolutions.

28. Every 50 hours of operation as well as after a long idle [illegible] (up to 5—8 days) check the 4th-stage safety valve for its [illegible] action by actuating the valve for two or three times; [illegible] the procedure just after starting the compressor.

[illegible] that the safety valve will get actuated, if for the first [illegible] lowing pressure existing in the 4th stage:
[illegible] 480 kg/sq cm with the safety valve adjusted for 485 [illegible]
[illegible] 260 kg/sq.cm with the safety valve adjusted for 225 [illegible]
[illegible] page of the present Description)
[illegible] pressure close the shut-off valve on the [illegible]

Stopping

29. Prior to stopping the compressor blow off and dry the air chambers of the cylinders and coolers. To this end proceed as follows:

(a) Five minutes before stopping open the 4th-stage blow-off valve as well as the divider blow-off valve available just behind the compressor, and close the shut-off valve in the delivery pipeline;

(b) Four minutes before stopping open in succession with one-minute intervals the blow-off openings on the 2nd- and 3rd-stage pressure gauge valves as well as the 1st-stage blow-off valve; let the compressor run with the blow-off valves opened for at least two minutes.

30. Switch off the electric motor.

31. Observe the pressure gauges and make sure that the pressure in all the stages has dropped down to zero.

32. Turn off the cock on the cooling water supply pipe.

33. Drain the water off the compressor for which purpose do as follows:

(a) open the drain cocks on the 3rd- and 4th-stage cylinders;

(b) open the drain cocks on the 1st- and 2nd-stage cylinders of both rows;

(c) unscrew the plug out of the water pump housing.

When the water is drained off, screw the plug home and close the cocks.

Note. If the compressor is supposed to stay idle for not longer than 12 hours and the ambient temperature is over 5° C, the water is not necessary to be drained off.

34. Take off the crankcase hatch cover and check by a thermometer (or to the touch) the temperature of the piston rod bearings and of the main bearings. This temperature should not exceed the ambient temperature by more than 50° C.

35. Thoroughly examine all the compressor moving parts. Special attention should be paid to the tightening of the piston rod bolt nuts.

If the nuts are found to get loose, take the piston rod bolts out and check them for soundness, put them back, tighten the bolt nuts well and cotter them.

36. Eliminate all the faults detected by examination or in the course of operation of the compressor.

Note. Procedure listed in Items 34, 35 and 36 are to be performed every 50 hours of operation after stopping the compressor.

37. Wipe the compressor with rags.

Emergency Stopping

38. The compressor must be stopped without delay in the following cases:

(a) when the sharp knocks are heard;

(b) when the pressure is higher (or lower) than that specified in the log-book (see Table of bench test data):

1st stage	by 1 atm
2nd stage	by 3 atm
3rd stage	by 5 atm

(c) when there is no supply of cooling water; the cooling water pressure has jumped up or dropped sharply.

Note. If the compressor is stopped because of a faulty cooling water supply element or because of lack of water in the cooling system with the temperature of the outer walls of the cylinders being over 40° C, it is absolutely forbidden to cool the heated compressor by delivering water into the water jacket spaces of the cylinders. The compressor is allowed to be started again only after it is quite cooled and its crankshaft is turned over by 2 or 3 revolutions by hand.

(d) the lubrication system pressure has sharply dropped (under 0.5 kg/sq. cm) or jumped up (above 1.0 kg/sq. cm) with the pressure valve of the oil pump being fully opened;

(e) in case of poor tightness, which results in a considerable leakage of air, oil and/or water;

(f) in case of one of the safety valves premature operation;

(g) in case of a breakdown of the rubber diaphragm in the 2nd-, 3rd- and 4th-stage cooler;

(h) in case of a sharp increase of the power consumed by the compressor;

(i) in case of some pressure gauge is out of order.

TROUBLES AND REMEDIES

Troubles encountered in the course of operating the compressor may result from various causes.

For a quicker location and elimination of most frequent faults there is Table 5, where some characteristic symptoms are given.

When eliminating some troubles listed below and/or replacing some elements and assemblies, follow the directions set forth in "Instructions for Servicing the Motor-Driven Compressor During Long-Term Idleness".

Table 5

Troubles and Remedies

No.	Symptoms of trouble	Cause of trouble	Remedy
1	A pressure rise in one stage only	(a) Untight suction or delivery valve in the next stage	(a) Check the suction and delivery valves of the next stage, eliminate the faults detected, replace the faulty valves if necessary
		(b) Clogged cooler of the respective stage failing to cool air adequately Note. In such a case the temperature of the air leaving the cooler shows a rise (this can be determined by a heating of the next-stage pipe)	(b) Flush the clogged cooler with kerosene and blow it off with compressed air
2	A pressure rise in the 1st and 2nd stages	(a) Clogged coolers of the 1st and 2nd stages failing to cool air adequately Note. This can be determined by a heating of the 2nd- and 3rd-stage suction pipes	(a) Flush the clogged coolers with kerosene and blow them off with compressed air
		(b) Untight suction or delivery valves of the 3rd stage	(b) Check the 3rd-stage suction and delivery valves. Eliminate the faults detected. Replace faulty valves, if necessary
3	A pressure rise in the 1st, 2nd and 3rd stages	(a) Untight compression rings of the 3rd-stage piston, faulty labyrinth type piston of the 4th stage or untight self-acting valves of the 4th stage	(a) Check the compression rings of the 3rd-stage piston, labyrinth-type piston of the 4th stage and self-acting valves of the 4th stage. Eliminate the faults detected. Replace faulty piston rings and/or valves, if necessary
		(b) Clogged coolers of the 1st, 2nd and 3rd stages failing to cool air adequately	(b) Flush the 1st-, 2nd- and 3rd-stage coolers with kerosene and blow them off with compressed air

Nos	Symptoms of trouble	Cause of trouble	Remedy
		(c) Poor supply or too high temperature of cooling water at the compressor inlet	(c) Take measures to cut down the temperature of cooling water entering the compressor
		(d) Untight suction and delivery valves of the 2nd, 3rd and 4th stages	(d) Check the 2nd-, 3rd- and 4th-stage self-acting valves. Eliminate the faults detected. Replace faulty valves, if necessary
4	A pressure rise in the 2nd and 3rd stages	(a) Untight suction and delivery valves of the 3rd and 4th stages	(a) Check the 3rd- and 4th-stage suction and delivery valves. Eliminate the faults detected. Replace faulty valves, if necessary
		(b) Clogged coolers of the 2nd and 3rd stages failing to cool air adequately	(b) Flush the 2nd- and 3rd-stage coolers with kerosene and blow them off with compressed air
5	A pressure rise in the 1st stage and a pressure drop in the 2nd stage	(a) Untight compression rings of the 1st-stage piston	(a) Check the 1st-stage compression rings. Eliminate the faults detected. If a ring is worn out or broken, replace it
		(b) Untight suction or delivery valves of the 2nd stage	(b) Check the 2nd-stage valves. Eliminate the faults detected
6	A pressure rise in the 1st and 2nd stage and a pressure drop in the 3rd stage	Untight compression rings of the 3rd-stage piston and untight suction or delivery valves of the 3rd stage	Check the compression rings of the 3rd-stage piston and valves of the same stage. Replace faulty rings and valves, if necessary
7	A pressure drop in the 1st, 2nd and 3rd stages	Untight suction or delivery valves of the 1st stage	Check the 1st-stage self-acting valves. Eliminate the faults detected. Replace faulty valves, if necessary
8	A pressure drop in the 2nd and 3rd stages	Untight compression rings of the 2nd-stage piston	Check the 2nd-stage compression rings. Replace faulty rings, if necessary

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Nos	Symptoms of trouble	Cause of trouble	Remedy
9	A marked fall of compressor output	(a) Untight compression rings of the 2nd-stage piston (the symptom is a pressure drop in the 2nd stage)	(a), (b) Check and measure the 2nd- and 3rd-stage piston rings and 4th-stage labyrinth-type piston. Replace faulty rings, if necessary
		(b) Untight compression rings of the 3rd-stage piston and/or untight labyrinth-type piston of the 4th stage (the symptom is a pressure drop in the 1st stage)	
		(c) Untight suction valves of the 1st stage (the symptom is a pressure drop in the 1st stage)	(c) Check the 1st-stage suction valves. Replace faulty valves or some valve elements, if necessary
		(d) Leakage of air through untight joints in the compressor piping	(d) Eliminate the leakage of air through untight joints. Replace faulty gaskets and packing, if necessary
10	A pressure gauge reads a considerably lower value or zero	A faulty pressure gauge	Replace the faulty pressure gauge
11	A pressure drop in the lubrication system	(a) Clogged filter	(a) Take out the filter, flush it with kerosene and blow it off with compressed air
		(b) Some poor seals in the lubrication system	(b) Eliminate the leakage of oil by curing the poor seals in the lubrication system
		(c) Broken spring of the oil pump by-pass valve	(c) Replace the spring
12	A pressure rise in the lubrication system	Clogged oil conduits in the crankshaft or piston rods	Flush the oil conduits with kerosene and blow them off with compressed air

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Nos	Symptoms of trouble	Cause of trouble	Remedy
13	A pressure drop in the cooling system	Suction of air into the water pump or into the suction pipe through some poor seals	Inspect the system and cure the poor seals detected
14	A pressure rise in the cooling system	Clogged cooling system, which results in a greater resistance for water to flow	Thoroughly clean and flush the compressor piping and water jacket spaces of both the cylinders and coolers; blow them off with compressed air
15	A sharp rise in pressure in the cooling system. Breakdown of the rubber diaphragm of the 2nd-, 3rd- and 4th-stage cooler	Considerable leakage of air: (a) out of the 2nd-stage cooler tubes or 3rd- and 4th-stage cooler coils because of damaged soldered joints or broken tubes; (b) out of the air chamber of the 1st-stage cooler into its tube bunch because of damaged soldered joints or broken pipes	Inspect the coolers. Eliminate the faults detected. Test the repaired units and the cooler assembled under hydraulic and air pressures, specified in the log-book (see section "Hydraulic and Air Tests"); install a new diaphragm
16	A greater power consumed by the compressor	(a) Poor cooling of compressed air in the coolers because of their getting clogged or a high temperature of the cooling water entering the water (the symptom is a higher pressure in the stages) (b) Untight self-acting valves of the 2nd, 3rd and 4th stages (the symptom is a higher pressure in the preceding stages)	(a) Take measures to reduce the cooling water temperature; if some coolers are clogged, flush them with kerosene and blow off with compressed air (b) Check the 2nd-, 3rd- and 4th-stage self-acting valves; eliminate the faults detected

Nos	Symptoms of trouble	Cause of trouble	Remedy
17	Knocks in the crankcase	(a) Worn-out piston rod bearings	(a) Readjust the diametral clearance between the crankpin and rod bearing in conformity with the Table 4 "Basic Clearances"
		(b) Loose bolts of the piston connecting rods often accompanied by a pressure drop in the lubrication system	(b) Tighten the nuts of the piston rod bolts
18	Knocks in the cylinders	(a) Broken self-acting valves of some stage and presence of a foreign matter inside the cylinder (the symptom is a sharp rise of pressure in the preceding stage)	(a) Inspect the self-acting valves which are in the stage next to that showing a pressure rise. Take the foreign body out of the cylinder. If the tapered portion of the piston has bad dents, take the piston out, clear the dents off and measure its diameter. If the piston diameter grows larger (which is probable for the 1st-stage piston) and the compression rings are jammed in the grooves because of being deformed, file away the piston until its outer diameter is that specified in the log book and scrape off the grooves to bring the total ring side clearance to the value specified in the Table "Basic Clearances"

No.	Symptoms of trouble	Cause of trouble	Remedy
		(b) Misadjusted (too small) axial clearance between one of the pistons and the cylinder cover	(b) Measure and readjust the axial clearance between the piston and the cylinder cover in conformity with the Table "Basic Clearances"

Notes:

1. Unlightness of suction and delivery may result from:

a) wear of a valve;

b) breakdown of a valve;

c) sticking of a valve disc to the cup, which is caused by accumulation of oil and/or carbon deposits in the valve;

d) deformation of spring.

2. Unlightness of compression rings may result from:

a) wear of rings;

b) poor elasticity of rings;

c) breakdown of rings;

d) rings sticked to or jammed in the piston grooves because these are dirty;

e) notches available in the friction surfaces of the cylinders.

3. Pressure gauges may read lower values because of some unlight joints both inside the compressor and in the piping system. Such unlight joints may be located by hissing of the air escaping therefrom.

INSPECTION AND MAINTENANCE PROCEDURES

The compressor is to be repaired for the first time after 1000 hours of operation, provided it has been stored, installed and operated in a proper way, preventative inspections having been carried out every 250 hours of operation.

To secure a troublefree operation during the above term each compressor is delivered complete with a set of spares, which may be utilized in the process of inspection and maintenance procedures.

The inspection and maintenance procedures are to be scheduled as below.

(a) after 250 hours of operation: a preventative inspection;

(b) after 500 hours of operation: a preventative maintenance;

(c) after 750 hours of operation: another preventative inspection;

(d) after 1000 hours of operation: current repairs.

Dismantling and reassembling of the compressor for inspection and maintenance procedures should be carried out in conformity with the corresponding section of the present Instructions.

The electric equipment should be inspected and maintained in conformity with the Instructions issued by the Manufacturer thereof.

Data on inspection and maintenance procedures performed should be noted down in the log-book for the compressor or that for the electric equipment.

Important! After 30 hours of operation following both an initial installation of the motor-driven compressor on board and a replacement of valves in the course of scheduled preventative inspection and maintenance procedures, tighten all the self-acting valves to make them fit to their seats (the 1st-stage suction valves are allowed not to be tightened since there are some difficulties in removal of the air receivers).

Preventative Inspection After 250 Hours of Operation

1. Disconnect and take off the air and cooling water pipelines which are connected to the covers and cylinders of the 3rd and 4th stages, suction manifold and coolers of the 1st and 2nd, 3rd, 4th stages.
2. Remove the 1st and 2nd, 3rd, 4th stage coolers.
3. Take off the suction manifolds.
4. Replace the self-acting valves of ~~all the~~ [redacted] stages. Mount all the valves and their plugs with the use of graphite powder mixed in white spirit.
5. Remove the 3rd- and 4th-stage cylinder covers.
6. Take off the 3rd- and 4th-stage cylinders and check the friction surfaces of their liners.
7. Check the 3rd-stage piston rings.
8. Turn over the crankshaft to move the pistons down and check the friction surfaces of the 1st-stage cylinder liners.
9. Take off the cover of the crankcase hatches and check the piston rod bolts for adequate tightening.
10. Inspect the 4th-stage labyrinth-type piston. If there are some notches, burrs of the like on the friction surface of the labyrinth-type piston, which may effect on the compressor work, never eliminate them by filing.
11. Measure the liner and the 4th-stage labyrinth-type piston to determine the diameter clearance between the 4th-stage labyrinth-type piston and the liner, which should not exceed the value specified in the Description.

If it is necessary to replace the labyrinth-type piston with a new one, see that the diameter clearance between the liner and the piston be within 0.05 to 0.072 mm.

12. Check in the 2nd—3rd—4th-stage cooler (by paint) the groove surfaces of each rubber arrester are pressed to the 3rd and 4th-stage cooler coil turns.

To check an arrester take all the other ones out of their seats; the arrester under check should be freely put into its seat and pressed to the coil turns by hand.

Prior to taking the arresters out of their seats, see that there are serial numbers marked on both the arrester and the seat flange butt, which marks are available on one end only.

If some of the arrester groove surfaces are not pressed to the coil turns in an adequate way, fit it with the help of a round file so that the arrester edge be at least 2 mm above the seat flange butt; if the value is under 2 mm, place a rubber spacer on the arrester, which spacers are available in the set of spares.

Important! If no one arrester groove surface is pressed to the 3rd- and 4th stage cooler coil turns, the coils may get broken.

If the air chambers of the cylinders or of the coolers and/or the interiors of the pipes have proved to be coated with scale, they are to be cleaned thoroughly.

Assemble the compressor in the reverse order. Cover all the friction surfaces with a thick coat of compressor oil.

During assembly of the compressor fill the air chambers of the coolers with oil:

the 1st-stage cooler with 0.5 kg, and
the 2nd-stage one with 0.25 kg.

When the compressor is assembled, check all accessible joints for adequate tightening of their fasteners.

Preventative Maintenance After 500 Hours of Operation

Inspect the moving parts, water and oil pumps, cylinders of all the stages, crankshaft tail seal (at the pumps end), 1st-, 2nd-, 3rd- and 4th-stage coolers and 4th-stage water-and-oil separator. Replace the self-acting valves of all the stages and the 4th-stage labyrinth-type piston.

To perform the above procedures a partial dismantling of the compressor is necessary for which do as follows:

1. Disconnect and take off the air, cooling water and oil pipes, which are connected to the covers and cylinders of the 3rd- and 4th-stages and to suction manifold, 1st and 2nd, 3rd, 4th-stage coolers the water and oil pumps.
2. Remove the 1st and 2nd, 3rd, 4th stage coolers.
3. Remove the suction manifold.
4. Remove the 3rd- and 4th-stage cylinder covers.
5. Remove the self-acting valves of all the stages.
6. Take off the 3rd- and 4th-stage cylinders.

7. Remove the covers of the crankcase hatches and uncouple the piston rod bearing halves.

8. Take out the piston of both the rows together with their connecting rods.

9. Remove the water and oil pumps.

10. Disconnect and remove the transmission cover.

11. Disconnect and take off the 4th-stage water-and-oil separator.

12. Take off oil catcher and wash it.

After the partial dismantling is over, wash and clean thoroughly all removed units and elements, inspect them and measure their surfaces to see that the dimensions are in conformity with those specified in the log-book.

If there are some notches, burrs or the like on the rubbing surfaces, eliminate the burrs and make the notch edges round by scraping or by treating them with a barette file.

If the air chambers of the cylinders or of the coolers and or the interiors of the pipes have proved to be coated with scale, they are to be cleaned thoroughly.

Note. It is advisable to clear compressor parts off carbon deposits in a 20% sodium hydroxyde solution warmed up to 70 or 80° C. which procedure should be followed by washing the parts treated first in cold and then in hot water. Parts made of aluminium alloys should be cleaned only with the help of a wooden trowel, moistened in kerosene.

11. All the data from the above inspection are to be entered into the log-book (Inspection and Maintenance Data), which data will serve as a guidance for repair work.

Inspection of Cylinders

If there are some notches, burrs or the like on the friction surfaces of the cylinders and cylinder liners, eliminate them by scraping or by treating them with a barette file. Then wash the friction surfaces with white spirit and blow them off with compressed air.

If the friction surfaces of the 3rd- and 4th-stage cylinder liners have such defects, which cannot be eliminated without violation of the allowable clearance values, these should be replaced with new ones.

Take the liners out of the cylinders with the help of special puller.

Note. The 3rd- and 4th-stage cylinder liners available in the set of spares are delivered completely finished and require no further treatment after they are inserted into their cylinders.

When replacing the 3rd-stage or 4th-stage cylinder liners, see that the clearance between the pistons and the liners be within the limits specified in Table 4, "Basic Clearances".

Inspection of Pistons and Connecting Rods

Inspect thoroughly the elements of the pivot joints and piston journal bushes. If there are some defects on the friction surfaces, replace the faulty elements.

Notches, burrs and the like on the friction surfaces of the 1st-, 2nd and 3rd-stage pistons should be eliminated, if necessary, by treating them with a barette file.

Check the 1st-, 2nd- and 3rd-stage piston rings for their dependability. If the piston rings have carbon deposits, which results in a poor mobility thereof, it is advisable to clear the rings and the piston grooves off the carbon deposits by the method described above (see Note to Item 10, p. 48).

Note. On replacing, if necessary, the 1st, 2nd- and 3rd-stage compression rings, check the new rings for a free travelling along the corresponding piston grooves.

Should there is a necessity, it is allowable to scrape the surfaces of the piston grooves, provided the ring side clearance will remain within the limits specified in Table 4, "Basic Clearances".

Check the bearings of both rows.

Inspection of Valves

When performing the preventative maintenance, replace all the self-acting valves with new ones.

Note. If a replacement takes place in a period between inspection and maintenance procedures dealing with some separate valves or their elements, the disc travel in new valves should be equal to the values thereunder (mm):

in the 1st-stage suction valves	$2^{+0.2}$
in the 2nd-stage suction valves and 1st- and 2nd-stage delivery valves	$1.5^{+0.2}$
in the 3rd-stage suction valves	$1.3^{+0.05}$
in the 3rd-stage delivery valves	$1.5^{+0.05}$
in the 4th-stage suction valves	$1.4^{-0.1}$
in the 4th-stage delivery valves	$1.2^{+0.05}$

The travel of a new valve disc is not to exceed the specified value by more than 0.05 mm.

When the valve elements are replaced and the valve is reassembled, punch the check nut available in the valve body (see Album of Drawings, Sheets 11, 12, 13, 14, 15 and 16).

Inspection of Crankshaft

Inspect the crankpin, crankshaft tail and packing rings. If there are some notches or burrs, eliminate them with a barette file and then grind with fine emery paper with the help of metal clips.

Scrape (to the paint) the friction surfaces of the piston rod bearing liners to fit the crankpin. After scraping, while reassembling the compressor, check the radial clearances between the pistons and cylinders of the 1st stage for conformity with the values specified in Table 4 "Basic Clearances".

The clearance between the friction surfaces of the piston rod bearing liners and the crankpin is also to correspond to the value given in Table 4, which should be achieved by varying the number of gaskets to be placed between the piston rod bearing halves.

Inspection of Water and Oil Pumps of 1st, 2nd, 3rd- and 4th-stage Coolers, 4th-stage Water-and-Oil Separator and Other Auxiliaries

Inspect the friction surfaces of the elements of the water and oil pumps as well as of the transmission cover (at the places of friction of the crankshaft tail packing rings).

Check the water pump packing rings and the sealing gland of the oil pump reducing valve.

If the packing ring rubber is badly worn out or becomes too hard, replace the rings.

Check the surfaces of the balls of the water-and-oil separator non-return valve, 4th-stage blow-off valve and pressure gauges of all the stages. If there are traces of erosion, replace the balls.

Blow off all the air and oil pipelines.

Clean the 2nd-, 3rd- and 4th-stage cooler surfaces which are in contact with water from oxides and deposits. Prior to taking the arresters out of their seats, see that there are serial numbers marked on both the arrester and the seat flange butt, which marks are available on one end only.

When the 2nd-, 3rd- and 4th-stage cooler is inspected and reassembled, see (to the paint) that the groove surfaces of each rubber arrester are pressed to the 3rd- and 4th-stage cooler coil turns.

To check an arrester take all the other ones out of their seats, the arrester under check should be freely put into its seat and pressed to the coil turns by hand. If some of the arrester groove surfaces are not pressed to the coil turns in an adequate way, fit it with the help of a round file or replace with a new one taken from the set of spares and fitted to the corresponding coil turns.

Both the old arresters and new ones should be fitted so that their edges be at least 2 mm or 5 mm, respectively, above the seat flange butts; if the value is under 2 mm, place a rubber spacer on the arrester, which spacers are available in the set of spares.

Important! If no one arrester groove surface is pressed to the 3rd- and 4th-stage cooler coil turns, the coils may get broken.

Inspect the pipe bunch of the 1st-stage cooler; clear the inter-pipe space off sediments and dirt.

Assemble the compressor in the order reverse to the dismantle. Coat all the friction surfaces with a thick layer of compressor oil.

During assembly of the compressor fill with oil all the cavities as indicated in the section "Current Repairs After 1000 Hours of Operation".

Preventative Inspection After 750 Hours of Operation

Procedures to be performed are similar to those included in the preventative inspection after 250 hours of operation.

Current Repairs After 1000 Hours of Operation

The purpose of the current repairs is to replace worn-out parts and to re-establish an adequate operation of the motor-driven compressor. To carry out the current repairs it is necessary to dismantle the compressor completely. Dismantle the compressor in conformity with section "Dismantling and Assembling" of the "Instructions for Servicing the Compressor During Long-Term Layout".

Wash, clean and inspect thoroughly each part; carry out all the measurements required in conformity with the log-book; examine each part to see whether it is usable for further service or should be repaired, determine a kind of the repair needed.

All the measurement data as well as the faults detected are to be noted down in the log-book.

Replace every part which is badly worn-out (see Table 4, "Basic Clearances") or has such defects which cannot be eliminated.

Replace the self-acting valves of all the stages, the 1st-, 2nd- and 3rd-stage piston rings and the 4th-stage labyrinth-type piston.

While assembling the compressor, pour oil:

(a) into the air spaces of the coolers: of the 1st-stage (0.5 kg), of the 2nd stage (0.25 kg);

(b) into the oil pump chamber (up to the delivery pipe union);

(c) into the crankcase pan (up to the top mark on the dip-stick);

(d) into the water pump bearing space (0.25 kg);

(e) into the crankshaft bearings (with an oil gun, the crankshaft being turned over by hand).

After repairing the compressor and prior to putting it into service, carry out running-in and setting-up tests to let the friction surfaces get worked-in and to check the compressor parameters for their conformity with those specified.

The compressor should be tested for at least 5 hours, including;

30 minutes for running-in at no counter-pressure in the 4th stage;

1 hour for running at a pressure of 50 kg/sq. cm in the 4th stage;

1 hour for running at a pressure of 100 kg/sq. cm in the 4th stage;

1 hour for running at a pressure of 200 kg/sq. cm in the 4th stage;

30 minutes for running at a pressure of 300 kg/sq. cm in the 4th stage;

30 minutes for running at a pressure of 400 kg/sq. cm in the 4th stage.

Check an output capacity of the compressor and an ability for work of the 4th-stage safety valve.

Note down the test data in the log-book.

If the test results are found satisfactory, the compressor may be commissioned for further service.

2. INSTRUCTIONS FOR SERVICING THE COMPRESSOR DURING LONG-TERM IDLENESS

GENERAL ATTENDANCE

1. Every day inspect the compressor as it is seen from the outside and wipe it, keep the room where the compressor is installed clean.

2. Every day turn over the crankshaft by 10 or 15 revolutions with the blow-off valves of all the stages being open.

Once a week start the compressor to lubricate all the moving and friction parts as well as to blow off the working cylinders thereby avoiding corrosion. Start and stop the compressor in compliance with the directions presented in sections III and IV of the "Instructions for Servicing the Motor-Driven Compressor in Operation".

Keep the compressor running for some 15 or 20 minutes at a delivery pressure of 50 kg/sq. cm.

3. If the compressor is supposed to stay idle for longer than two months, preserve it by slushing.

Note. Prior to putting the preserved compressor into operation remove the slushing compound in compliance with the directions presented in the "Instructions for Servicing the Motor-Driven Compressor in Operation".

4. All the attendance procedures performed in the period of idleness of the compressor are to be noted down in the board log-book.

DISMANTLING AND ASSEMBLING

When dismantling the compressor, place removed parts and elements in complete sets using special cases or racks; take care that the parts were not knocked against each other in order to avoid dents, notches and the like, especially when handling some parts having friction surfaces such as the crankshaft, pistons, cylinders, cylinder liners, etc.

After the compressor is dismantled, wash all the parts in white spirit and wipe them dry with clean rags. It is advisable to clear compressor parts (except the parts made of aluminium alloys) off carbon deposits in a 20% sodium hydroxide solution warmed up to 70 or 80° C, which procedure should be followed by washing the parts treated first in cold and then in hot water.

General Dismantling

While dismantling inspect carefully every packed joint; take out the packing gaskets and examine them to make sure that they are usable; replace faulty gaskets with new ones.

While reassembling put the gaskets onto their proper places and in the same number they were in before.

It is advisable to anneal copper gaskets prior to placing them back.

1. Drain water and oil off the compressor; to this end do as follows:

(a) open the gauge cocks on the 3rd- and 4th-stage cylinders and on the 2nd-, 3rd- and 4th-stage cooler;

(b) open the drain cocks on the 1st- and 2nd-stage cylinders of either row;

(c) unscrew the water pump protector;

(d) unscrew the drain plug out of the pan;

(e) unscrew the drain plug out of the oil cooler housing;

(f) unscrew the drain plug out of the coarse oil filter.

After water and oil are drained off, screw the plugs and protector back.

2. Take off the air pipes.

3. Take off the 1st- and 4th-stage water-and-oil separators.

4. Take off the water pipes.

5. Take off the oil pipes and oil catcher.

6. Take off the silencer together with its T-joint.

7. Take off the 1st-, 2nd- and 4th-stage coolers and their supporting brackets.

8. Take off the air receivers.

9. Unscrew the plugs available above the 3rd- and 4th-stage valves, take the stop springs out of the 3rd-stage valve seats and unscrew the valves.

10. Unscrew the plugs available above the 1st-stage valves, take out the stop springs and unscrew the valves.

12. Unscrew the plugs available above the 2nd-stage suction and delivery valves, take out the stop springs and unscrew the valves.

13. Take off the 3rd- and 4th-stage cylinder covers.

14. Take off the 3rd- and 4th-stage cylinders.

15. Take off the crankshaft hatch covers.

16. Remove the cotters and unscrew the nuts of the piston rod bolts.

Take of the lower halves of the piston rod bearings.

17. Carefully take out the pistons of the 1st, 2nd and 3rd stages and of the 1st, 2nd and 4th stages together with the connecting rods and top halves of the rod bearings. When doing so, take every measure to prevent the crankshaft from being knocked and the friction surfaces of the cylinders and their liners from getting scratched.

18. Take off the top halves of the rod bearings and take out the rod bolts.

19. Take off the 1st- and 2nd-stage cylinders of both rows.

20. Take off the water pump.

21. Take off the oil pump.

22. Take off the oil cooler.

23. Take off the transmission cover.

24. Take out the bolts fastening the crankcase to the bed plate.

25. Displacing the crankcase disconnect the compressor half-coupling and the electric motor half-coupling.

Lifting the crankcase remove the pan.

26. Unscrew the bolt fastening the compressor half-coupling and take the half-coupling off the crankshaft with the help of a special tool device; take out the cotter.

Unscrew the nuts, take the washers off the studs fastening the bearing seat and take the whole of the crankshaft out of the crankcase with the help of jack bolts available in the kit of special tools.

Dismantling of Principal Units

Dismantling of Piston Assemblies

27. Take off the piston rings of the 1st, 2nd and 3rd stages.

28. Unlock and unscrew the nuts of the studs fastening the pivots and take off the pivot together with the piston rods.

29. Take out the piston pins thereby disconnecting the piston rods from the pivots.

30. Unscrew the lock screw and dismantle the top ball joint of the 4th-stage piston.

31. Unbend the lock washers and dismantle the lower ball joint of the 4th-stage piston and both the ball joints of the 3rd-stage piston.

Note. Prior to dismantling the piston assemblies of the 1st, 2nd and 3rd stages and 1st, 2nd and 4th ones, check to see that there are reference marks on the 3rd- and 4th-stage piston rods, on the pivot surfaces and on the lower butt ends of the 2nd-stage pistons of either row. The marks serve as matching guides for the piston assembly components. If no marks are available, put them down before dismantling the pistons according to the directions presented on Sheets 9 and 10 of the Album of Drawings.

Dismantling of 1st- and 2nd-Stage Self-Acting Valves

32. Unscrew the suction valve seat and delivery valve arrester; take out the valve disc and spring.

Dismantling of 3rd- and 4th-Stage Self-Acting Valves

33. Unscrew the valve seat or arrester out of the body and take out the valve disc, springs and bushing.

Note. When dismantling the valves, take measures to keep the components of each valve in their complete sets; never interchange any components of different valves, otherwise it may result in a wrong stroke and poor tightness of the valve.

Dismantling of 1st-Stage Cooler

34. Take off the cooler covers.

35. Take out the tube bunch of the cooler.

Dismantling of 2nd-, 3rd- and 4th-Stage Cooler

36. Take the flanges off the 4th-stage coil unions.

37. Unscrew the nuts and take the packing rings off the 3rd- and 4th-stage coil unions at the end of the cooler housing flange.

38. Take off the fixing device of the 2nd-stage tube bunch.

39. Take off the covers of the 2nd-stage tube bunch compartment.

40. Take off the covers of all the rubber arresters of the 3rd- and 4th-stage coils.

41. Check to see that there are identical serial numbers marked on each rubber arrester and on the butt end of its seat flange.

Both the marks are to be situated on the same side. Take the arresters out of their seats.

42. Unscrew the nuts fastening the cooler housing cover (the 2nd-stage tube sheet) and take the 2nd-stage tube bunch and 3rd- and 4th-stage sections out of the housing with the help of jack bolts available in the kit of special tools.

While taking out the 2nd-, 3rd- and 4th-stage sections, make the coil unions get out of the housing flange by means of gentle knocking onto the union butt ends with a lead hammer to prevent the 3rd- and 4th-stage coils from extension, i. e. from an increase of the pitch.

43. Unscrew the nuts and take the packing rings off the 3rd- and 4th-stage coil unions at the end of the cooler tube sheet. Knock the unions out of their seats in the tube sheet with the help of a lead hammer.

Dismantling of Water Pump

44. Remove the cotter, unscrew the nut, take the pinion off the pump axle and pull out the spline.

45. Unscrew the nut, take off the washers and cover of the pump.

46. Unbend the lock washer, unscrew the special screw and take off the impeller with the help of a special puller.

47. Unscrew the nuts, take off the washers and unjoin the water pump housing from that of the bearings.

48. Take out the pump axle (towards the water pump housing end).

49. Take out the ball bearings and the spacer.

50. Take the packing rings out of the water pump housing.

Dismantling of Oil Pump

51. Remove the cotter, unscrew the nut, take off the drive pinion and remove the spline.

52. Unscrew the screws fastening the pump cover, remove the cover and take out the axles together with the pinions.

53. Unscrew the check nut of the by-pass valve gland.

54. Unscrew and take out the adjusting screw together with the gland.

55. Unscrew the gland shell.

56. Take out the spring together with the ball.

Dismantling of Oil Cooler and Oil Filter

57. Unscrew the nuts and take off both cooler covers.

58. Take off the fixing strip.

59. Take the section out of the cooler housing.

60. Unscrew the nuts and take out the filtering element.

Dismantling of Crankshaft

61. Unscrew the bolts, remove the butt cover together with the packing ring and take off the bush and the rubber ring which seals the bush on the shaft.

62. Take off the bearing seat together with the bearing with the help of a special puller (see Album of Drawings, Sheet ~~41~~ 40).

63. Take the bearing out of its seat.

64. Take off the rings from the crankshaft tail.

65. Unbend the lock washer, unscrew the nut, take off the driving pinion and remove the spline.

66. Take off the thrust washer.

67. Take out the bearing with the help of a special puller (see Album of Drawings, Sheet ~~42~~ 41).

Note. Take the bearings off the crankshaft, when it is necessary only.

Assembling the Compressor

When assembling the whole of the compressor or some of its units, use only the parts and elements which are sound. Never use any worn-out or faulty parts.

To determine usability of worn-out parts apply to Table 4, "Basic Clearances".

Just prior to assembling, cover all the friction surfaces with a thick coat of compressor oil.

In the process of assembling keep the working place and tools as well as parts removed clean to prevent dirt from getting into the compressor interior.

Assembling the Units

Assemble separate units in the order reverse to that described in section "Dismantling of Principal Units".

General Assembling

1. Put the assembled crankshaft into the crankcase. When doing so, make use of six bolts (ЭК 10.11.00.09) available in the kit of special tools by screwing them into the threaded holes in the crankcase, which holes are intended for the studs fastening the bearing seat. After the crankshaft is put onto its place, fasten the bearing seat by means of the studs.

Notes.

1. Prior to fastening the bearing seat, check to see that the mark on the seat does match with those on the end cover and the crankcase.

2. After the bearing seat is fastened, check the crankshaft for a free and easy rotation. Under the gravity effect exercised by the counterweights the

crankshaft is to make a few swings with respect to its axis from an initial position with the counterweights and the piston rod stem being horizontal. To obtain an easy rotation it is allowable to shift the outer roller bearing race towards the drive pinion of the pumps by knocking on the race at the pinion end, knocks being delivered from the inside.

3. After the transmission cover is fixed, check the crankshaft for any easy rotation again.

2. Put the transmission cover onto its place and fasten it.

3. Install the oil cooler together with the oil filter onto the crankcase pan and fasten it.

4. Fix the pan to the crankcase.

5. Insert the spline into its slot in the crankshaft; mount the drive half-coupling on the crankshaft and fasten it.

6. Install the crankcase on the bed plate and couple the crankshaft with the electric motor shaft by joining the half-coupling of the compressor with that of the electric motor. Fix the binding bolts and fasten the crankcase to the bed plate.

7. Install the oil pump and fasten it.

8. Install the water pump and fasten it.

9. Install the 1st- and 2nd-stage cylinders of both the rows and fasten them. To seal the joint between the cylinders and the crankcase put a packing gasket made of drafting paper under each cylinder.

Fix the pipes *A* and *Б* (see Album of Drawings, Sheet 33).

10. Fix the 1st-, 2nd- and 3rd-stage pistons and 1st-, 2nd- and 4th-stage ones together with the connecting rods into the 1st- and 2nd-stage cylinders of either row so as the top halves of the rod bearings lie with their liners on the crankpin.

Notes.

1. Prior to fixing the pistons, check to see that:

(a) the marks on the pivots do match with those on the lower butts of the 2nd-stage pistons;

(b) the adjusting strips between the rod stems and the top halves of the rod bearings are placed in conformity with the serial numbers marked thereon:
Strip No. 3 — for the 1st-, 2nd- and 3rd-row piston assembly;
Strip No. 4 — for the 1st-, 2nd- and 4th-row piston assembly

(c) Match the marks on the 3rd- and 4th-stage pistons with those on the 3rd- and 4th-stage piston rods.

2. When putting the pistons together with their rods into the cylinders, see that the curvatures (R=2) available on the rod backings do face the crankshaft webs.

3. When putting the pistons together with their rods into the 1st- and 2nd-stage cylinders, fix the 1st-stage piston rings with the help of a bushing (ЭК10.11.00.21) by inserting it into an opening available in the 1st-stage cylinder. Fix the 2nd-stage piston rings with the help of bars (ЭК10.11.00.22) through the 2nd-stage valve seats.

11. Mount the lower halves of the piston rod bearings on the crankpin and fasten them.

Cotter the nuts of the piston rod bolts.
See that the crankshaft rotates easily by hand.

Note. Tighten the nuts of the piston rod bolts with a special wrench the compressor is furnished with, do so by one hand only without any additional lever. Never overtighten the piston rod bolts.

12. Check the dead space in the 2nd-stage cylinders of either row (see Note to Item 17 below).
13. Put the covers of the crankcase hatches onto their places and fasten them.
14. Install the 3rd- and 4th-stage cylinders and fasten them.
15. Check the dead space in the 1st-stage cylinders of either row (see Note to Item 17 below).
16. Put the covers of the 3rd- and 4th-stage cylinders onto their places and fasten them.
17. Check the dead space in the 3rd- and 4th-stage cylinders.

Note. The adequate values of the dead space are specified in the log-book. Measure the dead space as follows.
Insert a lead wire 1.5 mm in diameter into the cylinder interior through the openings for the self-acting valves, the pistons being shifted by one half revolution of the crankshaft with respect to the dead space to be measured. Turn over the crankshaft by one revolution, take out the wire and measure a thickness of the squeezed portion thereof.

18. Screw in the suction and delivery valves of all the stages, put the stop springs above the 1st-, 2nd- and 3rd-stage delivery valves and above the 2nd- and 3rd-stage suction ones, screw in the plugs. When screwing in the valves and plugs, use graphite powder mixed with white spirit.
19. Install the air receivers onto the 1st- and 2nd-stage cylinders.
20. Screw in the 2nd- and 3rd-stage safety valves into the unions on the 2nd- and 3rd-stage cylinder covers, respectively.
21. Install the 2nd-, 3rd- and 4th-stage cooler and the 1st-stage one and fasten them.
22. Install the oil catcher and fix the lubrication system pipes. Fasten the pipes *A*, *Б*, *B* and *C* (see Album of Drawings, Sheet 33).
23. Fix the cooling system pipes.
24. Install the 1st- and 4th-stage water-and-oil separators.
25. Install the silencer together with its gauze filter and T-joint.
26. Fix the air pipes.

Installing the Compressor on Board

1. Install the compressor on board on shock absorbers in conformity with the dimensional drawings (see Album of Drawings, Sheets 38, 39 ~~and 40~~).

2. When lifting the compressor together with the electric motor, take care that a rope skirting the bottom part of the bed plate did not damage the compressor piping.

3. The lifting hook should be right above the centre of gravity of the compressor set, which centre is shown in the dimensional drawing (see Album of Drawings, Sheets 38, 39 ~~and 40~~).

4. A compressor foundation should have an even and horizontal surface.

5. Arrange the compressor set in the room so as to secure a free access to all its units and joints, as well as easy dismantling thereof.

Install the pressure gauge panel outside the compressor but so as to secure a convenient watch over the pressure gauge readings in the process of operating the compressor, and to secure a free access to the valves mounted on the panel.

6. See that the sea water intake opening of the cooling system valve be always submerged in water and protected against fouling.

7. If the water pump of the compressor is situated above the waterline, the intake pipe should be fitted with a non-return valve situated under the waterline (the intake pipe is not delivered by the Manufacturer).

8. The water pump intake pipe should have no local lifts which may contribute to formation of air locks, nor sharp bends, which may increase resistance for water flow.

Between the non-return valve and the water pump there should be no other intake branches.

The water pump intake pipe should be fitted with a filtering gauze and provision should be made for a convenient inspection and cleaning thereof, which procedures are necessary just before starting the compressor.

9. For the emergency cases (a failure of the water pump) there should be made a provision for cooling the compressor from some other water supply source, water pressure and water consumption being 1 to 1.5 kg/sq. cm and 80 to 100 litres per minute, respectively. In such a case water should proceed directly to the 1st- and 2nd-stage cylinders of the 1st-, 2nd and 4th-stage row, escaping the water pump. The underwater portion of the pipe should have a branch running to the oil cooler of the compressor. The water pump should be removed, the opening in the transmission cover being plugged.

10. When the compressor is supposed to be installed on shock absorbers, see that the compressor bed plate be resting well on the supporting strips of the absorbers.

It is allowable to lay gaskets between the bed plate and the supporting strips of the shock absorbers.

3. INSTRUCTIONS ON ANTICORROSION TREATMENT AND REMOVAL OF SLUSHING COMPOUND

ANTI-CORROSION TREATMENT

General

1. The motor-driven compressor is slushed to protect its parts against corrosion while being transported, stored or during long-term standstill up to 1 year.

2. Carry out all slushing procedures in a room where the ambient air temperature is not less than +8° C. Keep the room perfectly clean to prevent any dirt and/or dust from getting into and onto the compressor under treatment.

3. The electric motor should be treated in compliance with the methods generally accepted for slushing of electric equipment.

Materials Used for Anticorrosion Treatment

4. Use for anticorrosion treatment the following lubricants:
(a) slushing oil K-17 (ВТУ НП 113-62) or K-19 (ВТУ НП 77-62);
(b) clean rags;
(c) rubber of 3 mm thick to stop the silencer at exhaust;
(d) paraffined paper (ГОСТ 9569—60) or parchement (ГОСТ 2995—56);
(e) diesel fuel "ДС" or "ДЗ" (ГОСТ 4749—49).

Notes.
(a) Prior to slushing the K-17 or K-19 oil should be tested in laboratory for absence of moisture.
(b) Before taking a sample the K-19 oil should be elaborately mixed up.

Internal Slushing at Manufacturer's or on the Site of Installation

5. The internal slushing is accomplished by operating the compressor employing the slushing oil K-17 or K-19 in place of usual oil, for this purpose proceed as follows:
a) drain the usual oil, employed for the compressor operation, off the pan, the oil filter and oil cooler with the compressor being hot;
b) fill the pan with slushing oil up to the level of 25 mm above the oil gauge lower lever (7 kgs, approx.);
c) prepare for starting and start the motor-driven compressor (in accordance with the servicing Instructions) and operate it with rated speed for an hour and at pressure of $P_{1y} = 0$ kg/sq. cm.

2. When lifting the compressor together with the electric motor, take care that a rope skirting the bottom part of the bed plate did not damage the compressor piping.

3. The lifting hook should be right above the centre of gravity of the compressor set, which centre is shown in the dimensional drawing (see Album of Drawings, Sheets 38, 39 ~~and 40~~).

4. A compressor foundation should have an even and horizontal surface.

5. Arrange the compressor set in the room so as to secure a free access to all its units and joints, as well as easy dismantling thereof.

Install the pressure gauge panel outside the compressor but so as to secure a convenient watch over the pressure gauge readings in the process of operating the compressor, and to secure a free access to the valves mounted on the panel.

6. See that the sea water intake opening of the cooling system valve be always submerged in water and protected against fouling.

7. If the water pump of the compressor is situated above the waterline, the intake pipe should be fitted with a non-return valve situated under the waterline (the intake pipe is not delivered by the Manufacturer).

8. The water pump intake pipe should have no local lifts which may contribute to formation of air locks, nor sharp bends, which may increase resistance for water flow.

Between the non-return valve and the water pump there should be no other intake branches.

The water pump intake pipe should be fitted with a filtering gauze and provision should be made for a convenient inspection and cleaning thereof, which procedures are necessary just before starting the compressor.

9. For the emergency cases (a failure of the water pump) there should be made a provision for cooling the compressor from some other water supply source, water pressure and water consumption being 1 to 1.5 kg/sq. cm and 80 to 100 litres per minute, respectively. In such a case water should proceed directly to the 1st- and 2nd-stage cylinders of the 1st-, 2nd and 4th-stage row, escaping the water pump. The underwater portion of the pipe should have a branch running to the oil cooler of the compressor. The water pump should be removed, the opening in the transmission cover being plugged.

10. When the compressor is supposed to be installed on shock absorbers, see that the compressor bed plate be resting well on the supporting strips of the absorbers.

It is allowable to lay gaskets between the bed plate and the supporting strips of the shock absorbers.

3. INSTRUCTIONS ON ANTICORROSION TREATMENT AND REMOVAL OF SLUSHING COMPOUND

ANTI-CORROSION TREATMENT

General

1. The motor-driven compressor is slushed to protect its parts against corrosion while being transported, stored or during long-term standstill up to 1 year.

2. Carry out all slushing procedures in a room where the ambient air temperature is not less than +8° C. Keep the room perfectly clean to prevent any dirt and/or dust from getting into and onto the compressor under treatment.

3. The electric motor should be treated in compliance with the methods generally accepted for slushing of electric equipment.

Materials Used for Anticorrosion Treatment

4. Use for anticorrosion treatment the following lubricants:
(a) slushing oil K-17 (ВТУ НП 113-62) or K-19 (ВТУ НП 77-62);
(b) clean rags;
(c) rubber of 3 mm thick to stop the silencer at exhaust;
(d) paraffined paper (ГОСТ 9569—60) or parchement (ГОСТ 2995—56);
(e) diesel fuel "ДС" or "ДЗ" (ГОСТ 4749—49).

Notes.
(a) Prior to slushing the K-17 or K-19 oil should be tested in laboratory for absence of moisture.
(b) Before taking a sample the K-19 oil should be elaborately mixed up.

Internal Slushing at Manufacturer's or on the Site of Installation

5. The internal slushing is accomplished by operating the compressor employing the slushing oil K-17 or K-19 in place of usual oil, for this purpose proceed as follows:
a) drain the usual oil, employed for the compressor operation, off the pan, the oil filter and oil cooler with the compressor being hot;
b) fill the pan with slushing oil up to the level of 25 mm above the oil gauge lower lever (7 kgs, approx.);
c) prepare for starting and start the motor-driven compressor (in accordance with the servicing Instructions) and operate it with rated speed for an hour and at pressure of $P_{ly} = 0$ kg/sq. cm.

In this case the pressure shown by the oil pressure gauge arranged on the compressor gearbox cover should be within the limits of 1.0 to 1.3 kg/sq. cm.

Note: The manufacturer can perform anticorrosion treatment during a check test (after detection of defects); in so doing, the compressor should be operated in the course of the last 10 to 15 minutes with the pressure $P_{1v}=0$ kg/sq. cm; lubrication of the compressor is to be effected during the whole period of check tests with the slushing oil at pressure P=1.0 to 1.3 kg/sq. cm.

6. Stop the motor-driven compressor, in accordance with the Instructions for Servicing the motor-driven compressor in operation, accomplishing carefull scavenging of cylinders before stopping during not less than 5 minutes.

7. Cut the electric motor off the supply mains; disconnect: the air pipe, which runs from the 4th-stage water-and-oil separator to the air bottles, the pressure gauge pipes, the blow-off pipes coming from the 1st-stage and the 4th-stage water-and-oil separators pipe connections, and the inlet and outlet hoses of the water cooling system.

8. Drain the cooling water off the cooling system with the help of compressed air, having pressure $p<1$ kg/sq. cm, blown through the drain pipe of the 1st-stage cooler with the drain cocks of the cylinders and coolers being stopped and the water pump drain plug being unscrewed as well. (The system is to be blown off until water flow from the drain cocks comes to an end, with the cocks being opened).

9. Drain the slushing oil off the crankcase pan, cooler and oil filter. Replace drain plugs.

10. Bring the differential piston of the 1st, 2nd- and 3rd-stage row into its lower position and remove one (upper) suction valve from each 2nd- and 3rd-stages and one delivery valve of the 1st-stage.

11. With the help of a funnel at a grease gun fill through holes for valves the following spaces with slushing oil:

a) the 1st-stage cylinder space: 150 cu. cm;

b) the 3rd-stage cylinder space: 30 cu. cm.

Replace the removed valves of the 1st- and 3rd-stages, their stop springs and valve seat plugs in the presence of the representative of the Technical Inspection Department.

12. Bring the differential piston of the 1st-, 2nd- and 3rd-stage row to its upper position. With the help of a grease gun through the opening for valve fill the 2nd-stage cylinder space with 100 cu. cm of slushing lubricant. Replace the 2nd-stage valve, its stop spring and valve seat plug in the presence of the representative of the Technical Inspection Department.

13. Bring the differential piston of the 1st-, 2nd- and 4th-stage row to its lower position and remove one suction valve from back cylinder of the 2nd- and 4th-stages (upper ones) and one delivery valve of the 1st-stage.

14. By means of a funnel of grease gun through holes for valves fill the following spaces with slushing lubricant:

a) the 1st-stage cylinder space (150 cu. cm);

b) the 4th-stage cylinder space (15 cu. cm).

Replace the removed 1st- and 4th-stage valves, their stop springs and valve seat plugs in the presence of the representative of the Technical Inspection Department.

15. Set the differential piston of the 1st-, 2nd- and 4th-stage row into its upper position. By means of a grease gun through opening for valve fill the 2nd-stage cylinder space with 100 cu. cm of slushing lubricant.

Replace the 2nd-stage valve, its stop spring and valve seat plug in the presence of the representative of the Technical Inspection Department.

16. Turn over by hand the motor-driven compressor crankshaft for 5 to 6 revolutions.

17. Put a stopper, specified in the motor-driven compressor overall dimension drawing, on the pipe union of the compressor pipe lines to connect it to the pressure gauge pipes and to pipe connection of the 1st- and 4th-stage water-and-oil separator.

Plug with wooden stoppers two water outlet and one inlet openings of the compressor, as well as air outlet holes of the 4th-stage water-and-oil separator.

The silencer gauze should be closed with a stopper dia. 87×3 mm.

Note. When the motor-driven compressors are exported to the countries of tropical climate, the rubber plug and rubberized flexible hoses should be coated exteriorly with nirite paste. The wooden stoppers are to be impregnated with an antiseptic (salicylamide or chlordane) according to the technical specifications TY No. 50-1-59. KCM and HII, supplements 1 and 4.

External Slushing

18. External slushing consists in coating the compressor component surfaces with a thin layer of slushing lubricant. The following unpainted components should be coated: couplings of the compressor and electric motor shafts and internal surfaces of the safety valves.

The safety valves are slushed by immersing them into slushing lubricant and letting them immerse for a minute, then allowing the lubricant to run off, the valves are put into their seats.

19. To protect the slushed outer surfaces, they are to be wrapped in paraffined paper.

Notes:
a) In case of corrosion spots, they should be removed with the help of emery cloth 000 soaked in oil. Dressed points must be washed with Diesel fuel and wiped dry.
b) It is forbidden in the course of slushing to touch the slushed surfaces or to impair the slushing grease coat of these surfaces;
c) the rubberized flexible hoses are not to be coated with slushing grease

20. If any painted surface is damaged, it should be repainted.

Slushing of Spare Parts, Appliances and Special Tools

21. All spare parts, appliances and special tools, except those made of non-ferrous metals and stainless steel, are to be slushed as follows:
a) Wash the outer and inner surfaces with Diesel fuel, blow them off with compressed air and wipe dry;
b) coat the component surfaces with slushing compound by dipping them into the slushing lubricant. Then wrap them in paraffined paper or parchment and put them into appropriate seat in the box for spares and tools.

Note: It is not allowed to coat the rubber parts with slushing compound.

REMOVAL OF SLUSHING COMPOUND

22. Removal of slushing compound should be carried out prior to initial starting of the motor-driven compressor on board. It is absolutely forbidden to start the compressor before completing the procedures set forth below.
23. Prior to starting the motor-driven compressor proceed as follows:
a) remove plugs from the delivery and suction pipes of the cooling system;
b) take the rubber stopper off the gauze of the silencer filter and the stoppers off the pipe connections to which pressure gauge and blow-off pipe are to be connected;
c) install pipes connecting the compressor with the pressure gauge board and with the blow-off valves;
d) open the blow-off valves of the 1st- and 4th-stage water-and-oil separators;
e) turn over the compressor crankshaft by hand for 5 to 6 revolutions, making sure that no jamming and accumulation of slushing compound in the compressor cylinders take place;
f) fill the crankcase pan with usual (operating) oil;
g) connect the compressor to the cooling water pipe line;
24. Start the motor-driven compressor with counter-pressure $P_{IV}=0$ kg/sq. cm and operate the compressor at this operating

conditions for not less than 30 minutes letting the air into the atmosphere or drainage space.

25. Arrange air pipe between the 4th-stage water-and-oil separator and the air bottle section.

After all the above procedures are performed, the motor-driven compressor is ready for normal operation.

Storage at Customer's

26. The motor-driven compressor, auxiliary mechanisms, spare parts, special devices and tools must be stored in dry rooms free of gases and vapours causing corrosion.

The temperature in the rooms should be not below +5° C. The motor-driven compressors are allowed to be stored indoors in exceptional cases only in mild season, for no longer than a month; being kept in the Manufacturer's packing boxes.

27. In case of damage to the packing case in transit, the customer should thoroughly inspect the state of the external slushing of the compressor and if any fault is found the slushing should be renewed in conformity with the present Instructions.

28. Every six months the motor-driven compressor should be inspected for proper slushing (absence of corrosion). For this purpose except the external inspection it is necessary to remove the crankcase inspection hole covers and carefully examine (without dismantling) the accessible points of the connecting rod crankshaft and the 2nd-stage cylinder liners. If no fresh corrosion traces are found on the slushed surface of the components, the inspection hole covers should be replaced and carefully scaled.

Note: In the course of inspection it is forbidden to touch the slushing coat or somewhat injure it on the anticorrosion treated surfaces.

If any fresh corrosion is found on the components inside the crankcase the motor-driven compressor should be completely dismantled and examined for defects and assembled. Than it should be reslushed according to the present Instructions.

GUARANTEE

29. The Manufacturer guarantees the safety of the compressor, auxiliary mechanisms, spare parts and tools slushing compound coating provided the requirements of the present Instructions are properly followed.

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Modifications and Errata

Page	Line or table	Fault	Read
3	table 1	ЭК10-1	ЭК10-1М
	table 1	МП39,5/25	ЭП39,5/25М
4	table 2	ЭК10-1	ЭК10-1М
	table 2	1230	1360
13	9 line from top	...above (see para 9)	... above
15	3 line from top	...then into the outlet pipe.	...then into the sight glass 183 and outlet pipe.The glass serves for visual control of cooling water flow.
16	18line from bottom	...and covers 148	... covers 148 and 155

Modifications and [illegible]

Page	Line or table	Fault	Read
16	8 line from bottom	148	155
16	4 line from bottom	The adequate tightness... ...jacket space.	The tightness of the "floating" tube sheet is accomplished by a ring 146.
17	1 line from top	Tightness of packing... ...cover 148.	annihilated
17	7 line from top	148	148 and 155.
17	9 line from top	of cover 148	of covers 148 and 155.
21	10 line from bottom	sheets 24 and 15	sheets 24 and 35

Modifications and Errata

Page	Line or table	Fault	Read
31	23 line from top	When the oil pressure has risen...	When the oil pressure has fallen...
44	12 line from top	See Note to Item 10, p.48	See Note to Item 12.
46	2 line from top	...off sedi-ments and dirt. Assemble the compressor...	...off sediments and dirt. Sections of 1 and 2 stage coolers, 3 and 4 stage coiled coolers should be tested for strength and tightness to the pressure, indicated in the Log-book in the table "Hydraulic and Air pressure test." Assemble the compressor..

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